Attachment 2

FINAL REPORT

City of Edmonton Comprehensive Parking Study – Phase I

February 2019

NELSON
NYGAARD

Report: CR_6707

Table of Contents

Table of Figures

1 INTRODUCTION

BACKGROUND

The City of Edmonton initiated a citywide assessment of parking supply and demand trends in 2018-19. As in many North American cities, Edmonton's parking requirements are extremely detailed and prescriptive, establishing varying minimums per square meter or other unit (e.g., seats) for many land use categories. Based on a large body of research showing that parking requirements rarely reflect actual parking need[1] and decrease mobility options, City staff initiated this study to determine if Edmonton's existing parking regulations: 1) reflect observed parking utilization across the City's many neighbourhoods; 2) align with actual need; and 3) support broader City goals that promote more compact, walkable neighbourhoods

The first phase of work focused on a review of data collected by the City in 2018 to identify key trends and variables that might have correlations with parking demand. The second phase of work (to be determined) will focus on use of data to develop formal recommendations on citywide parking regulations.

GOALS

This study aims to answer several key research questions:

1. Does off-street parking utilization have a relationship to indicators of urban activity, such as population and employment density?
2. Does off-street parking utilization have a relationship to the type of land use considered?
3. Where, when, and how much off-street parking is utilized in Edmonton?
4. How much off-street parking is supplied and utilized relative to the type and size of different land uses?

[1] Rachel Weinberger and Joshua Karlin-Resnick (2015), Parking In Mixed-Use U.S. Districts: Oversupplied No Matter How You Slice The Pie, Transportation Research Board Annual Meeting.

SUMMARY OF KEY FINDINGS

1. **Parking is over-supplied across geography and land uses considered.** Based on observed data, parking is generally over-supplied across most land uses and locations in Edmonton. Some specific sites or neighbourhoods have high parking occupancies at certain times of day. However, those findings are not reflective of overall citywide patterns and are indicative of site-specific management challenges.
2. **Parking is supplied and utilized at rates that have no discernable relationship with land use or neighbourhood context.** This report analyzes parking supply and utilization in relation to many potential land use and demographic factors. The consistent finding is that parking supply and utilization varies widely across the city and there is no easily identifiable, consistent factor determining this relationship.
3. **The City should prioritize further evaluation of a substantial reduction and/or elimination of minimum parking requirements.** As demonstrated in the analysis, there is wide variation in how parking is supplied and utilized by both land use and geographic area, and the relationships considered in this report are very tenuous.

   Therefore, parking supply should be primarily determined by local market demand, not prescriptive supply ratios in code. Parking regulations should ultimately provide flexibility for each site or project, while reflecting broader policy goals to reduce driving and promote mobility choices.
4. **City parking regulations and parking management practices can play a stronger role in how parking is utilized.** Where parking is utilized at a high rate (which was rare among sites analyzed), the City should consider pricing on-street parking, incentivizing the pricing of off-street parking, as well as regulations to manage parking demand, such as programs and infrastructure encouraging the use of transit, biking, walking, and shared vehicle trips. A Transportation Management Association (TMA), or some other organization directing management and regulation of on- and off-street parking as integrated inventory, would also help to maximize the utility of existing parking.

2 SUMMARY OF METHODOLOGY

PARKING SUPPLY AND UTILIZATION DATA

The primary dataset analyzed in this project was parking supply and utilization data collected by the City of Edmonton. The City team reviewed development applications and undertook several data collection efforts to generate the data included in this study. In brief, the City collected data from the following sources:

- **Development applications.** Development application records contain information about land use type, building characteristics, and parking supply. Where a development variance was requested, some applications include parking justification forms, which indicate the utilization on-site at a snapshot in time. The City extracted supply and utilization records from 54 different development sites.
- **Crowdsourced Data** - The City administered a communications campaign asking the public to identify locations and complete/submit count forms of parking facilities they had access to. The results were then processed into utilization data by City staff, resulting in 33 additional sites where utilization data were collected.
- **Parking Utilization Surveys.** City staff organized an internal team of surveyors to measure the parking characteristics associated with a number of developments and development-types. These surveys were completed during the summer and winter of 2018, resulting in utilization data from 277 unique sites.

These data were then processed and compiled into a Google Sheets database. The full details of the data gathering and collection efforts are summarized in the City team's data collection methodology, included in Appendix A. All parking utilization records' times of day were collapsed into four categories for ease of analysis and comparison:

1. Early AM– 5 a.m. to 10 a.m.
2. Mid-day – 10 a.m. to 4 p.m.
3. Early PM – 4 p.m. to 10 p.m.
4. Late PM – 10 p.m. to 5 a.m.

The final dataset is summarized by data source in Figure 2-1. Overall, there are 343 unique sites in the dataset, with a total of 1,834 utilization records.

Figure 2-1 Count of Utilization Records by Data Collection Type

Data Collection Type	# Utilization Records	Proportion of Utilization Records	# Sites	Proportion of Sites
Development Permit Data	352	19.2%	54	15.7%
Crowdsourced	808	44.1%	32	9.3%
Utilization Survey	674	36.8%	257	74.9%
Total	1,834	100.0%	343	100.0%

While this data represents a reasonably sized sample from a cross section of Edmonton neighbourhoods and land uses, the conclusions from this study are still limited by the observations collected. As discussed in Chapter 3, parking behavior varies widely and cannot be precisely predicted by built environment context. Parking behavior is influenced by a wide range of factors that are difficult to measure and consistently determine across context.

PREDICTIVE VARIABLES

One of the primary purposes of the study was to test the relationship of parking supply and utilization to geographic variables to identify potential trends in parking utilization across Edmonton. The geographic level of analysis selected to test relationships was the neighbourhood level. Edmonton has 396 neighbourhoods in all, 160 of which have one or more sites where parking utilization was surveyed for this project. The following section presents a map of all the neighbourhoods.

Six predictive variables were chosen to: 1) test their relationship with parking demand; and 2) for use in testing neighbourhood grouping schemes (discussed in the following section). These variables were all either directly sourced or aggregated at the neighbourhood level. The variables selected are described in Figure 2-2.

Figure 2-2 Predictive Variable Definitions

Variable	Source	Rationale
Population Density (people per km^2)	Neighbourhood Level Census Statistics	Population density is a typical indicator of urbanity – how dense is the concentration of people living in a particular neighbourhood? Denser places typically are better served by alternative modes of transport.
Employment Density (employees per km^2)		Employee density is also a typical indicator of urbanity – how dense is the concentration of jobs in a particular neighbourhood? Neighbourhoods with higher job densities are typically better served by alternative modes of transport.
Drive Alone Rate (%)		The neighbourhood's drive alone rate describes the proportion of residents in that neighbourhood who primarily travel alone via car. This measure can represent how auto dependent a neighbourhood is.
Walk Score	Sourced from walkscore.com for the geographic centroid of each neighbourhood geometry.	Walk Score is a well-known (but proprietary) measure of walkability – it aggregates several data sources to provide a proxy measure of the quality of the pedestrian environment. It is utilized to gauge the walkability and destination density of each neighbourhood.
Transit Score		Transit Score (developed by the same company as Walk Score) is a measure of transit accessibility. It aggregates information regarding transit frequency, density of stops and routes, and mode of service. It is used to gauge the transit accessibility of each neighbourhood.
Assessment Value Density ($/m^2)	City of Edmonton supplied shapefile with assessed value of every parcel.	The assessment value density measures how valuable ($ per square meter) the land is, on average, in a given neighbourhood. This is also a proxy for the activity level and centrality of the neighbourhood to the local/regional economy.

Walk Score and Transit Score Methodology details: https://www.walkscore.com/methodology.shtml

NEIGHBOURHOOD GROUPING

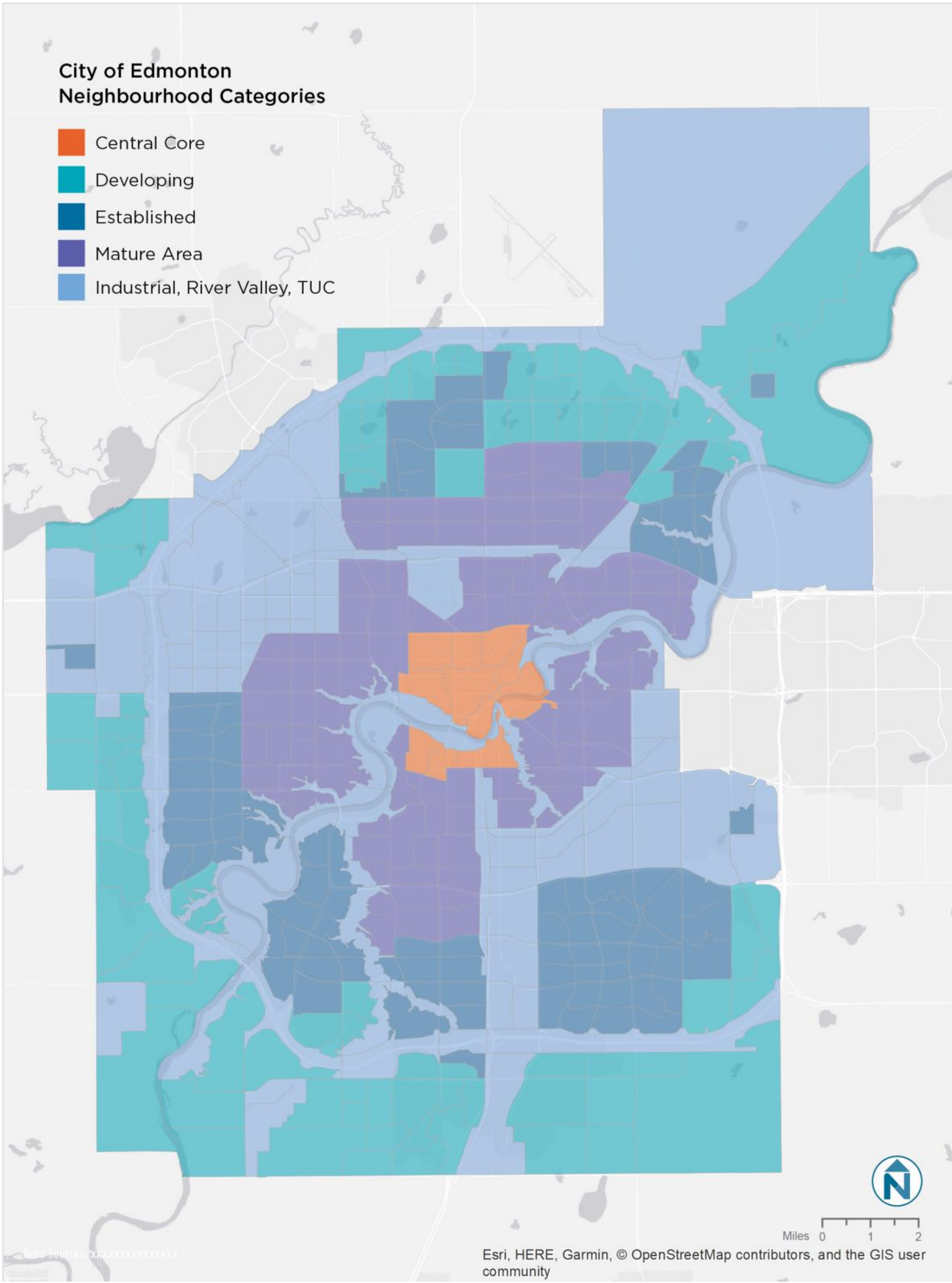
As stated in the previous section, the potential predictive variables were all tied to neighbourhood geographies. Given the limited resolution of parking utilization data collected, as well as the fact that the census statistics were only available at the neighbourhood level, data was aggregated to the neighbourhood level to attempt to make comparisons between a few aggregated statistics rather than solely among hundreds of different parking counts. As a result, instead of comparing 160 different neighbourhoods (the number of neighbourhoods with parking utilization data), a comparison between five groupings of 'similar' neighbourhoods could be made.

There were two different groupings of neighourhoods tested – one of which was supplied by the City, and the other which was developed based upon an analysis of the predictive variables discussed above. Each grouping classified every one of Edmonton's 396 neighbourhoods into five groups.

1. **City-developed classification:** this classification splits neighbourhoods into eight groups, five of which include parcels analyzed in this study. Those groups are defined in Edmonton's Municipal Development Plan, *The Way We Grow*. Descriptions of the groups from the 2015 Growth Monitoring Report are provided below. A map of the Edmonton's neighbourhoods and their groups is illustrated in Figure 2-3. Those five groups are:
    a. Core areas – Downtown and adjacent neighbourhoods.
    b. Mature areas – Neighbourhoods outside the core, generally completed prior to 1970.
    c. Established areas – Completed neighbourhoods, generally within the Anthony Henday Transportation Corridor.
    d. Developing areas – Currently developing and planned neighbourhoods where lot registration is not yet complete.
    e. Industrial areas – areas zoned for industrial uses.
2. **K-means clustering**: A statistical method (k-means[2]) was used to cluster neighbourhoods into groups based upon their values for the selected predictive variables. This method was used to attempt to detect groups of similar neighbourhoods (based on the variables considered) in a systematic and empirical way (as opposed to the City-developed classification). If there is a clear grouping of neighbourhoods, similar parking regulations (and other related regulations to the selected variables) may be applicable within those groups, which is useful for developing context-sensitive transportation policy and regulation. The final number of clusters and the predictive variables used in those cluster definitions, along with a map of the final clusters, are presented in the following chapter.

[2] K-means clustering is a statistical method for grouping observations into a pre-determined number of groups based upon their values for a defined number of variables. For more information: https://en.wikipedia.org/wiki/K-means_clustering

Figure 2-3 City of Edmonton Neighbourhood Categories Map



3 DATA ANALYSIS

The project team aimed to answer several questions with the data analysis:

1. Does observed parking utilization have a strong relationship with any of the hypothesized predictive variables?
2. Using the predictive variables selected, is there another way that neighbourhoods could be grouped to highlight key differences in parking supply and utilization?
3. Where, when, and how much parking is utilized relative to supply?
4. How much parking is supplied and utilized relative to the size and type of land uses?

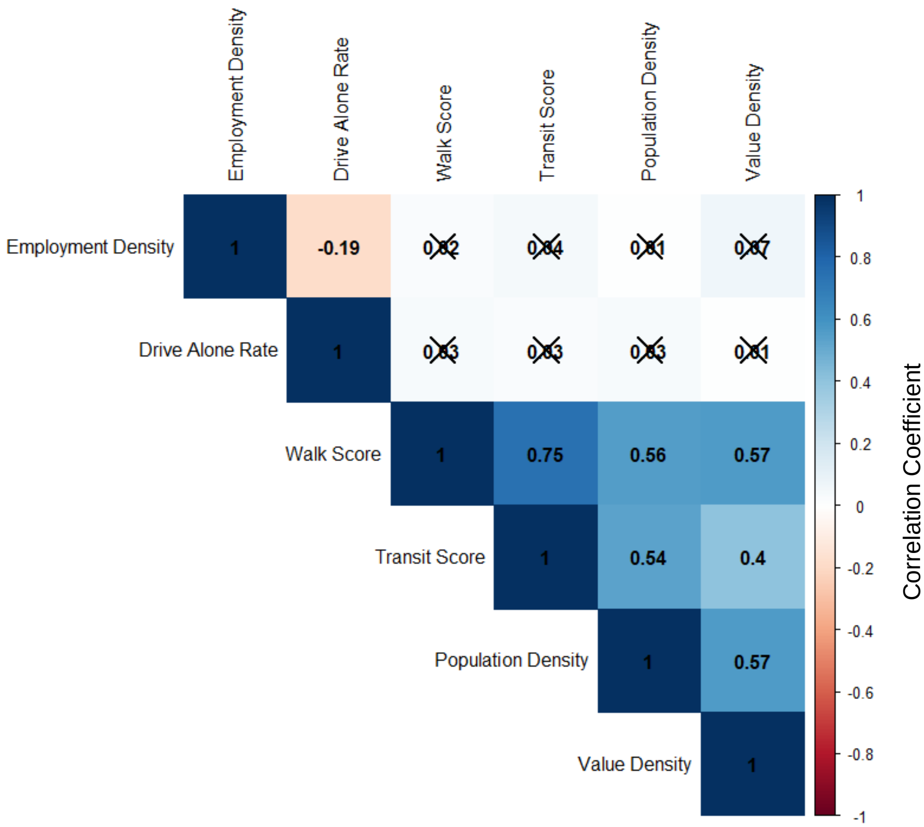
PREDICTIVE VARIABLES

Six hypothesized predictive variables were tested for their relationship with the maximum observed parking utilization observed in each neighbourhood. The primary way to test the hypothesis of a relationship between two continuous variables (i.e. parking utilization and one of the potential predictive variables) is a correlation test. Each of the variables may be predictive of parking utilization, and each might offer some unique predictive power in a statistical model, but there is also the likelihood that the variables selected are correlated with *each other*.

Therefore, before testing their relationship with parking utilization, it is necessary to gauge the variables' relationship with each other, as is illustrated in the correlation plot in Figure 3-1. With the exception of the resident-based drive alone rate, which is not correlated with Walk Score, Transit Score, or value density; all other variables are correlated with each other to a statistically significant degree (at the $p<0.05$ level). Nevertheless, the correlations between drive alone rate and employment density and all other variables are weak. The strongest correlations (i.e. a higher correlation coefficient) are between Walk Score and Transit Score (which are derived from overlapping data), and then between Walk Score, Transit Score, population density, and value density.

These correlations are all *positive*, meaning that as one variable increases (e.g., Walk Score), the other increases (e.g., population density). **The variables' correlation with each other indicates that not all variables will be necessary or useful to specify a predictive parking utilization model.**

Figure 3-1 Correlation Matrix of Predictive Variables



Notes: 1) An 'X" in the above plot indicates that a correlation is not statistically significant at the $p<0.05$ level.
2) Larger numbers and darker squares indicate a correlation that is higher in magnitude (i.e. a stronger correlation).

The following plots independently compare the maximum observed parking utilization of each neighbourhood[3] with that neighbourhood's value for each of the six predictive variables tested. Note the linear model specification on the plot – the R^2 (the square of the correlation coefficient) indicates the percentage of variation in the dependent variable (maximum observed parking utilization) explained by one of the six predictive variables (e.g., population density). The neighrbourhood category (as defined by the City) is also shown – making it clear that there is not a distinct divide on any of the selected variables in the neighbourhood groups as they are currently congifured (this will be explored in detail in the next section).

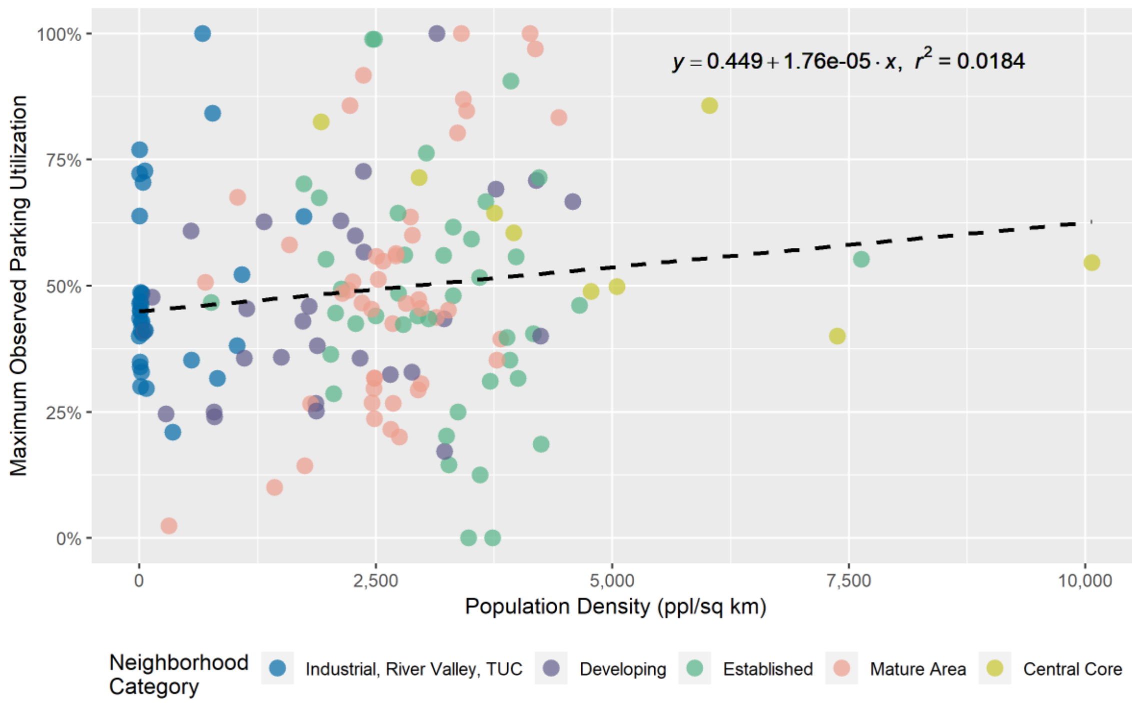
The strongest relationship is between **maximum observed parking utilization and Walk Score**. This indicates that destination density and land use mix – which Walk Score is a proxy for – may be the strongest predictor of the maximum observed parking utilization among those variables tested. Nevertheless, the correlation is still relatively weak – the correlation coefficient is 0.21 and the R^2 value is 0.045. This means only 4.5% of the variation in parking utilization is explained by the variation in neighbourhood Walk Score. This is visually apparent when looking at the scatter plot in Figure 3-5 – the linear relationship is not visually clear. The other

[3] Parking utilization was aggregated to the neighbourhood level by 1) summing the observed demand and supply at every site in a given neighbourhood, and then 2) dividing the total demand by the total supply. This results in a *weighted average* parking utilization assigned to each neighbourhood (for each time period surveyed). Note that when there is a single site, the neighbourhood utilization only represents that site.

relationships are weaker. Overall, these plots point to the evidence that, at least on their own, **none of the variables have strong predictive relationships with parking utilization.**

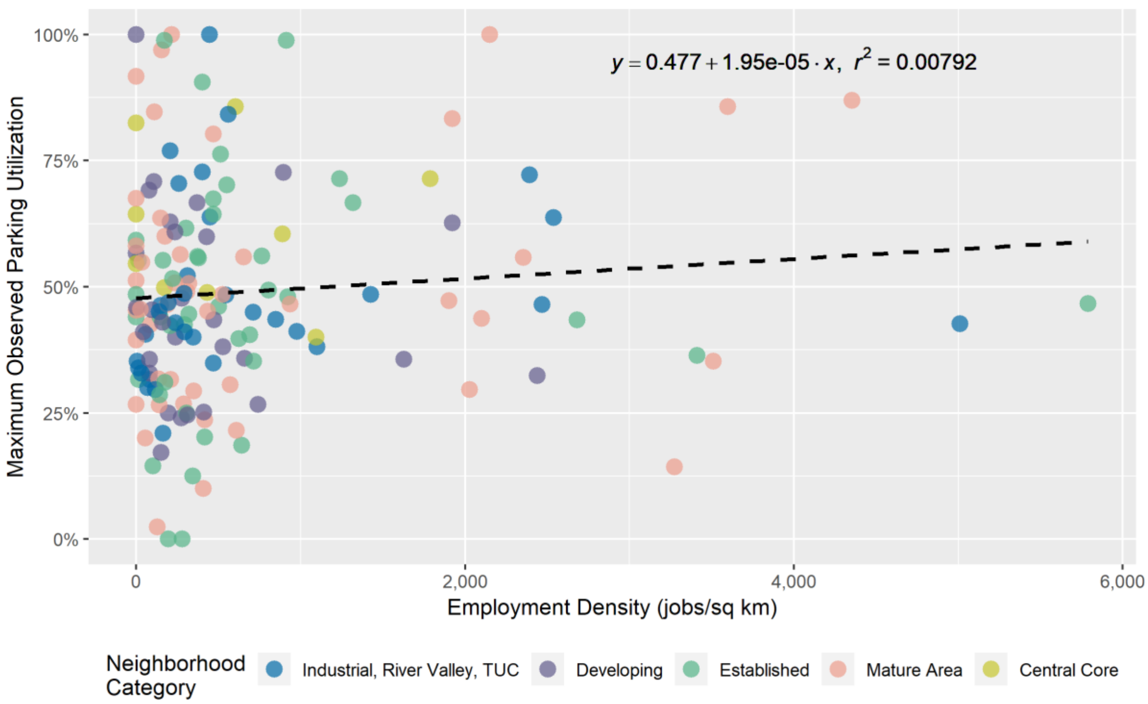
The demand ratio – which is the demand (in terms of number spaces) divided by the built area of the land use (in square meters) – was also tested in the same fashion. Its relation to the predictive variables was even weaker.

Figure 3-2 Scatter Plot of Maximum Observed Parking Utilization vs. Population Density



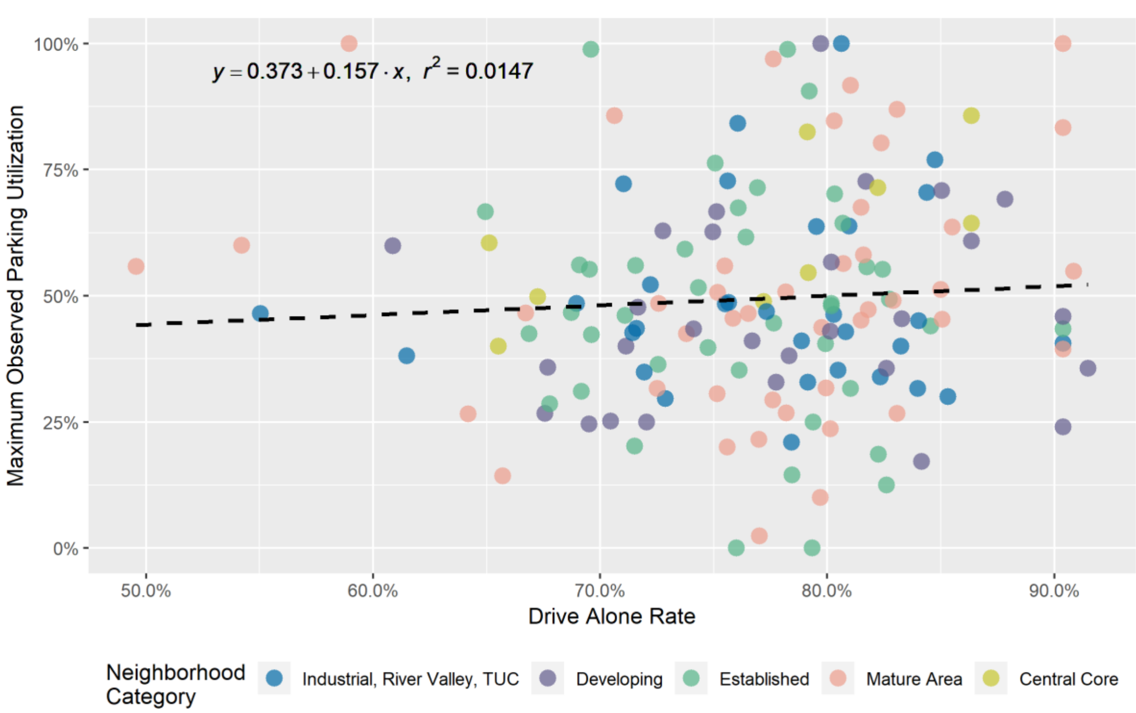
Note: Each point in the above plot corresponds to a neighbourhood.

Figure 3-3 Scatter Plot of Maximum Observed Parking Utilization vs. Employment Density



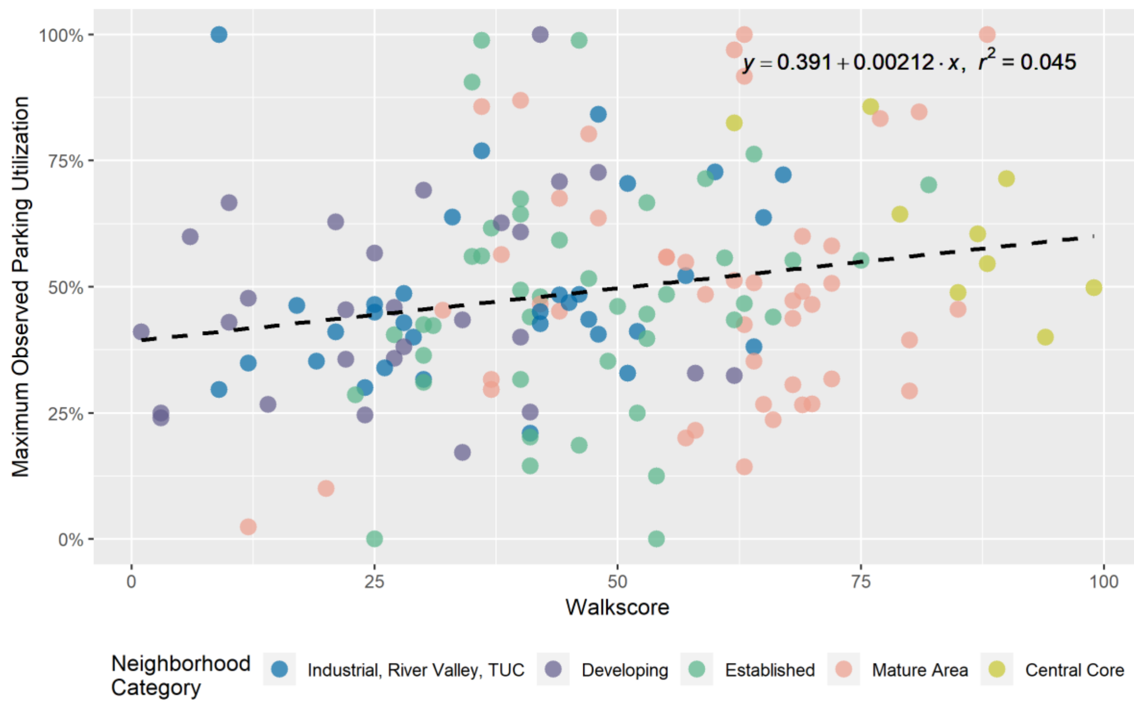
Note: Each point in the above plot corresponds to a neighbourhood.

Figure 3-4 Scatter Plot of Maximum Observed Parking Utilization vs. Drive Alone Rate



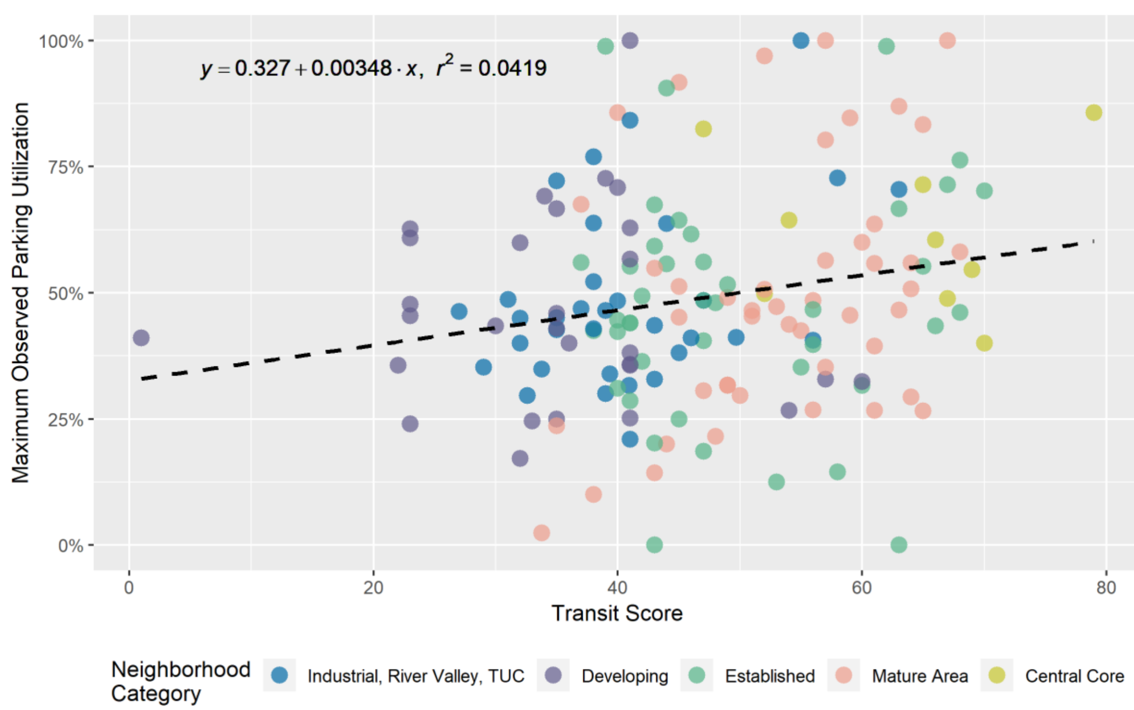
Note: Each point in the above plot corresponds to a neighbourhood.

Figure 3-5 Scatter Plot of Maximum Observed Parking Utilization vs. Walk Score



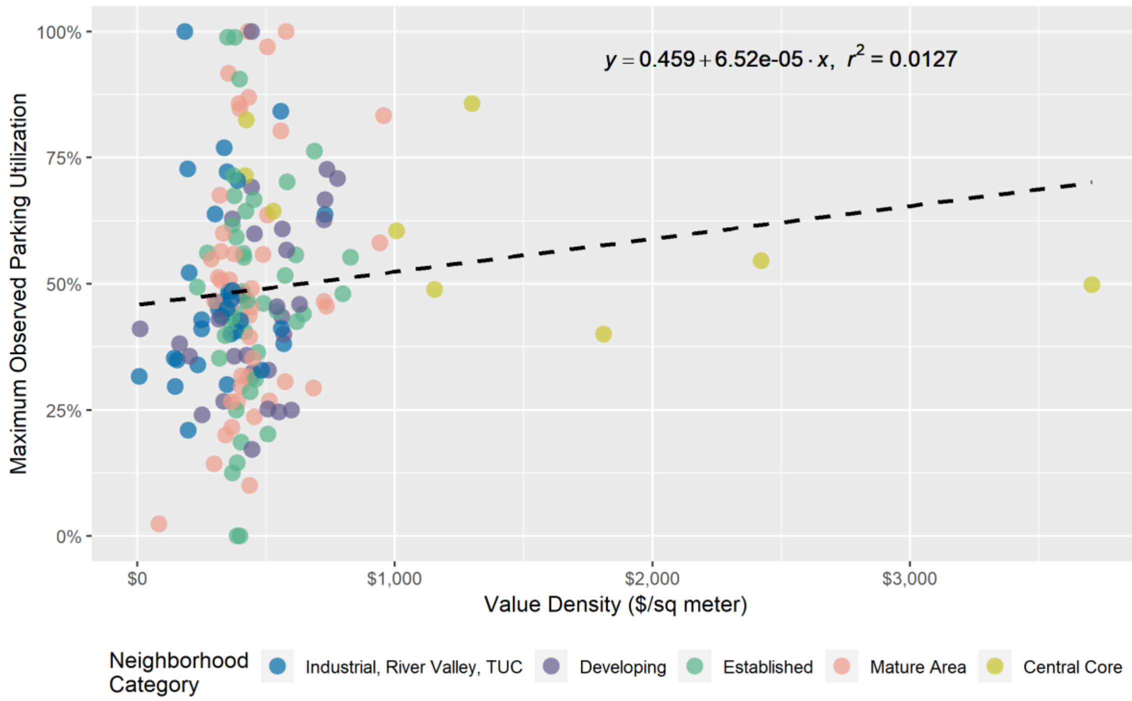
Note: Each point in the above plot corresponds to a neighbourhood.

Figure 3-6 Scatter Plot of Maximum Observed Parking Utilization vs. Transit Score



Note: Each point in the above plot corresponds to a neighbourhood.

Figure 3-7 Scatter Plot of Maximum Observed Parking Utilization vs. Value Density



Note: Each point in the above plot corresponds to a neighbourhood.

The final test of the predictive power of the variables selected was a multiple linear regression model, where the relationships of all six variables to parking utilization could tested simultaneously.

A typical process for testing multiple regression models is to test variables in a ‘stepwise’ fashion. Initially, all six variables were placed in the regression model simultaneously. Due to the phenomenon of multi-collinearity – where independent variables in a linear regression model are substantially correlated with each other – a regression model with more variables can actually have less explanatory power than one with fewer variables.

Using the Akaike Information Criterion (AIC), variables can be removed in ‘stepwise’ fashion – removing variables one at a time with the objective of maximizing the AIC value with the fewest variables used. This stepwise procedure was used to select the strongest model specification for maximum observed parking utilization, considering all six variables. This optimal model specification only included the Walk Score, indicating that, along with Walk Score being the most predictive variable, as discussed previously, **none of the other five variables add any unique explanatory power beyond the Walk Score.** The final model specification is presented in Figure 3-8.

The model results indicate much the same conclusion as the single variable scatter plots above – only 4.5% of the variation in the maximum observed parking utilization is explained by the variation in Walk Score. The model coefficient indicates that, on average, a one unit increase in Walk Score (a single point increase) results in a 0.0021 unit increase in parking utilization (i.e. a 0.21% increase).

Figure 3-8 Multiple Linear Regression Model Results – Peak Parking Utilization vs. Predictive Variables

Quantity	Value
Dependent Variable	Maximum Observed Parking Utilization (by Neighbourhood)
Walk Score	0.0021**
Constant	0.391
Observations	160
R^2	0.0447
Adjusted R^2	0.0386
Residual Std. Error	0.2096 (df = 158)
F Statistic	7.342*** (df = 1; 158)

Note: *p<0.1; **p<0.05; ***p<0.01

NEIGHBOURHOOD GROUPING

Cluster Classification

While the variables tested did not result in a strong predictive model for parking utilization, they were still used as a means for attempting to group the neighbourhoods into groups in a more empirical way than the City defined neighbourhood groups.

Using a K-means clustering algorithm (as described in Chapter 2), several different combinations of variables were used to attempt to group the neighbourhoods into relatively distinct/compact groups. The K-means process can be thought of as algorithmically trying to draw circles around groups of points in a scatter plot, except it can consider more than two dimensions (i.e. variables).

The process of considering multiple combinations of variables was iterative – starting with the strongest variable in terms of correlation to parking utilization (Walk Score) and adding in variables in order of correlation strength until the clusters began to overlap. The final combination of variables was using solely Walk Score and population density – population density had the third strongest relationship with parking utilization, but was not as strongly correlated with Walk Score as Transit Score, and so added some unique information to the cluster groupings.

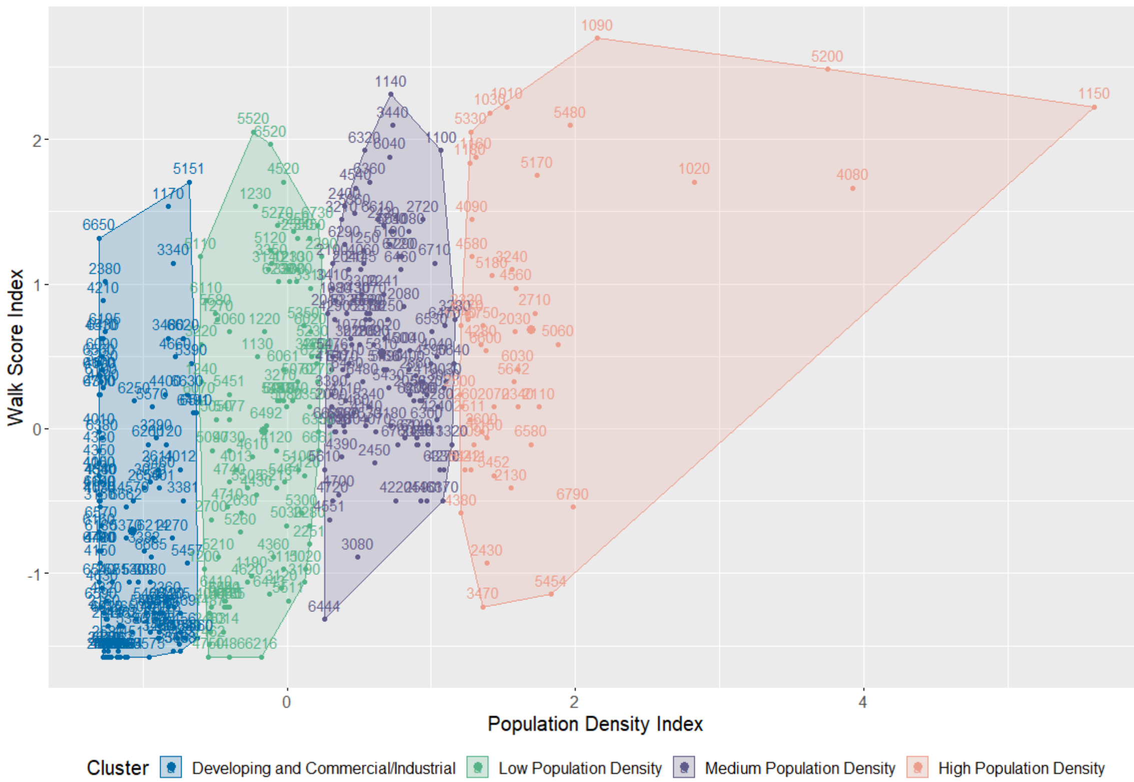
A visualization of the clusters on the basis of normalized Walk Score and population density is presented in Figure 3-9. Based on input from the City project team, four clusters were defined for the final cluster set. Each of the clusters was assigned a name based on input from the City project team and the summary statistics of each cluster detailed in Figure 3-10. The neighbourhoods are illustrated geographically in Figure 3-11.

The names developed for the clusters are purposefully imprecise – the groupings are coarse and neighbourhoods still vary widely within the clusters on other characteristics.

As discussed in Chapter 2, the aim of the K-means cluster analysis was to detect groupings of similar neighbourhoods (based on the values of the variables considered) through an empirical approach (as opposed to the City-developed classification). The results indicate that the primary factors differentiating neighbourhoods are population density and Walk Score, and only Walk

Score is correlated (albeit weakly) with parking utilization. This result lends credence to the conclusion that developing transportation policy for neighbourhood groups based on these variables would be inappropriate. Furthermore, prescribing parking regulations to neighbourhoods within these groups (as well as the City-defined groups, which have even less rigorous basis) is also misguided.

Figure 3-9 Visualization of Neighbourhood Clusters



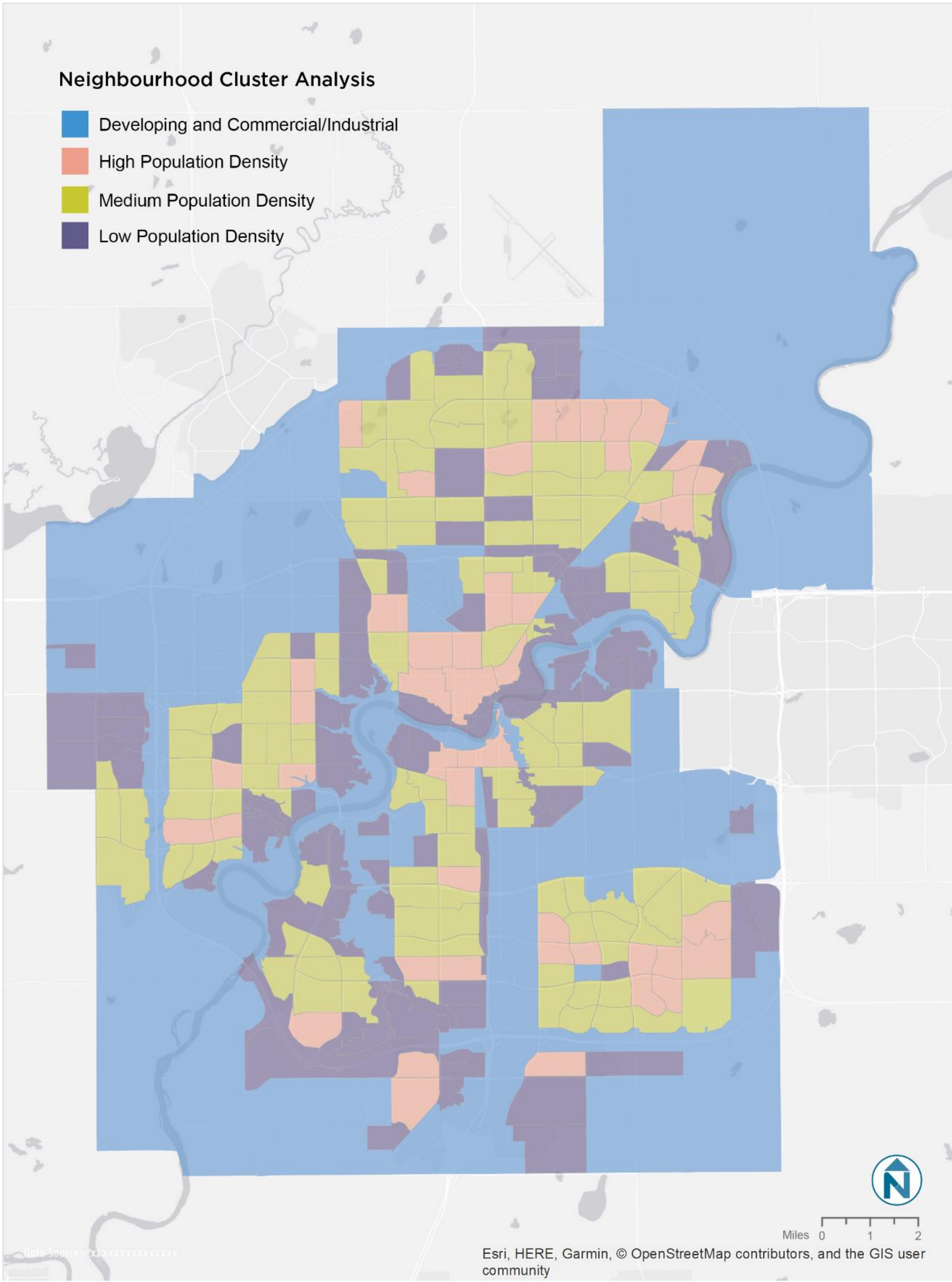
The K-Means clustering scheme has the benefit of being based on statistically rigorous consideration of descriptive data, **but results in neighbourhood groupings that are not geographically contiguous, which may be a drawback for making simple comparisons.** The cluster-defined grouping is more consistent with a generally one-directional trend in the predictive variables (when compared to a summary of the city-defined grouping in Figure 3-12). The cluster-defined grouping increases in the same direction for all the independent variables along with increasing density.

Both neighbourhood groupings were considered when examining utilization and supply and demand ratios.

Figure 3-10 Cluster Summary Statistics

Neighbourhood Group	# Neighbourhoods	# Parking Data Sites	Area (km²)	Population	Population Density (ppl./km²)	Employment (jobs)	Employment Density (jobs/km²)	Population / Employment (residents per job)	Drive Alone Rate among Residents	Walk Score	Transit Score	Value Density ($/m²)
Developing and Commercial/ Industrial	131	81	367.2	95,091	259	98,587	268	0.96	74.9%	10	27	$101
Low Population Density	101	62	116.1	192,763	1,660	91,139	785	2.12	75.0%	33	41	$374
Medium Population Density	116	107	134.5	388,698	2,890	122,948	914	3.16	74.6%	47	49	$437
High Population Density	48	88	58.1	250,426	4,311	123,756	2,130	2.02	66.4%	52	50	$750
Total	**396**	**338**	**675.9**	**926,979**	**1,371**	**436,430**	**646**	**2.12**	**73.4%**	**25**	**36**	**$271**

Figure 3-11 Neighbourhood Cluster Map



City Classification

A map of the city-defined neighbourhood classification is presented in the previous chapter (Figure 2-3). Summary statistics of the variables considered by city-defined neighbourhood groups are presented in Figure 3-12.

Both neighbourhood groupings were considered when examining utilization and supply and demand ratios.

Figure 3-12 City-Defined Neighbourhood Group Summary

Neighbourhood Group	# Neighbourhoods	# Parking Data Sites	Area (km^2)	Population	Population Density (ppl./km^2)	Employment (jobs)	Employment Density (jobs/km^2)	Population / Employment (residents per job)	Drive Alone Rate among Residents	Walk Score	Transit Score	Value Density ($/$m^2$)
Industrial, River Valley, TUC	103	72	253.4	77,882	307	78,275	309	0.99	74.5%	13	32	$92
Developing	89	58	201.4	219,276	1,089	76,792	381	2.86	74.2%	12	24	$237
Mature Area	100	90	108.8	274,474	2,523	120,656	1,109	2.27	75.1%	55	52	$434
Established	92	68	96.3	285,099	2,959	76,032	789	3.75	74.2%	39	47	$433
Central Core	12	50	16.1	70,247	4,375	84,675	5,274	0.83	57.2%	81	61	$1,438
Total	**396**	**338**	**675.9**	**926,979**	**1,371**	**436,430**	**646**	**2.12**	**73.4%**	**25**	**36**	**$271**

UTILIZATION TRENDS

The following section considers the trends in parking utilization by neighbourhood grouping method, by land use, and by time of year.

By Neighbourhood Group

Figure 3-13 and Note: Red shading indicates the peak utilization time period

Figure 3-14 summarize the weighted average[4] parking supply and utilization by neighbourhood group (city-defined) and cluster (respectively), as well as by time of day. **Overall, the maximum observed utilization observed when averaged across all sites was very low – 41% during the middle of the day.** When considering higher density neighbourhoods, utilization was closer to 50%.

Figure 3-15 and Figure 3-18 visualize the same data. The City-defined groups display a greater variation in the time of day utilization trends, but generally the **variance in utilization between neighbourhood groups is relatively small**. For example, in the City-defined neighbourhood groups, during the mid-day period the lowest utilization observed was in the Mature Area at 34.9%, while the highest utilization was in the central core was 53.5%. This is less than 20% of difference in parking utilization in significantly different looking neighbourhoods. The trends are even more similar at other times of day, and in the cluster-defined neighbourhood group.

Nevertheless, there is some wide variation in site-specific parking utilization - Figure 3-16 and Figure 3-19 show the distribution of maximum observed site parking utilization by neighbourhood group and cluster (respectively). Within each group there is a wide variation in utilization leading the relatively weak relationships of the predictive variables to parking utilization illustrated in the previous section. The distributions of utilization are non-normal (i.e. not shaped like a bell-curve), indicating that utilization will be difficult to predict on a statistical bases.

Parking utilization varies irrespective of the variables considered and neighbourhood boundaries. The vast majority of sites have parking utilizations that are less than the target occupancy of 90%[5].

[4] Throughout this document, the weighted average utilization refers to the sum of the demand divided by the sum of the supply, across all sites in a given neighbourhood or neighbourhood group.

[5] 90% is an industry standard target occupancy for off-street parking. Targeting 90% ensures there is always an available space for would-be parkers and that there is an adequate buffer in the parking system to accommodate typical fluctuations in daily/hourly demand.

Figure 3-13 Parking Utilization Summary, by City-defined Neighbourhood Group

Neighbourhood Group	Parking Sites	# of Parking Spaces Surveyed					Utilization of Surveyed Spaces				
		Early AM	Mid-day	Early PM	Late PM	@ Max Observed Utilization	Early AM	Mid-day	Early PM	Late PM	Max Observed
Industrial, River Valley, TUC	72	6,294	9,360	9,742	136	136	14.2%	44.1%	27.0%	52.2%	52.2%
Developing	58	2,413	11,803	10,622	3,018	3,018	11.9%	35.1%	23.6%	39.6%	39.6%
Mature Area	90	2,506	10,937	10,607	2,272	10,937	10.8%	34.9%	27.1%	27.7%	34.9%
Established	68	2,291	8,964	8,543	2,533	8,964	18.6%	43.8%	37.3%	36.9%	43.8%
Central Core	50	4,855	5,002	4,905	4,319	5,002	16.4%	53.5%	16.0%	43.9%	53.5%
Total	**338**	**18,359**	**46,066**	**44,419**	**12,278**	**46,066**	**14.5%**	**40.6%**	**27.0%**	**38.5%**	**40.6%**

Note: Red shading indicates the peak utilization time period

Figure 3-14 Parking Utilization Summary, by Cluster-defined Neighbourhood Group

Cluster Name	Parking Sites	# of Parking Spaces Surveyed					Utilization of Surveyed Spaces				
		Early AM	Mid-day	Early PM	Late PM	@ Max Observed Utilization	Early AM	Mid-day	Early PM	Late PM	Max Observed
Developing and Commercial/ Industrial	81	5,189	11,181	11,563	0	11,181	11.9%	38.0%	24.4%	-	38.0%
Low Population Density	62	2,827	9,275	8,851	2,387	9,275	12.5%	42.5%	27.0%	34.1%	42.5%
Medium Population Density	107	2,879	15,588	14,641	2,975	2,975	17.6%	36.2%	31.3%	48.9%	48.9%
High Population Density	88	7,464	10,022	9,364	6,916	10,022	16.0%	48.5%	23.4%	35.5%	48.5%
Total	**338**	**18,359**	**46,066**	**44,419**	**12,278**	**46,066**	**14.5%**	**40.6%**	**27.0%**	**38.5%**	**40.6%**

Note: 1) There were no Late PM observations for Developing and Commercial/Industrial Parking Sites.
2) Red shading indicates the peak utilization time period

Figure 3-15 Maximum Observed Parking Utilization (cumulative), by Time of Day and Neighbourhood Group (City-defined)

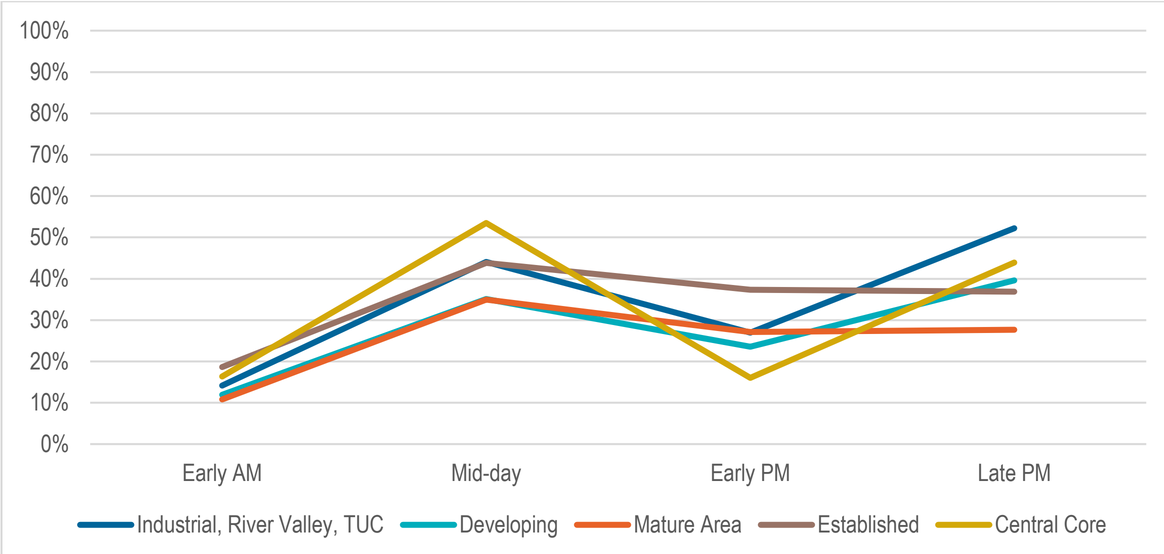


Figure 3-16 Histogram of Maximum Observed Site Utilization, by Neighbourhood Group (City-defined)

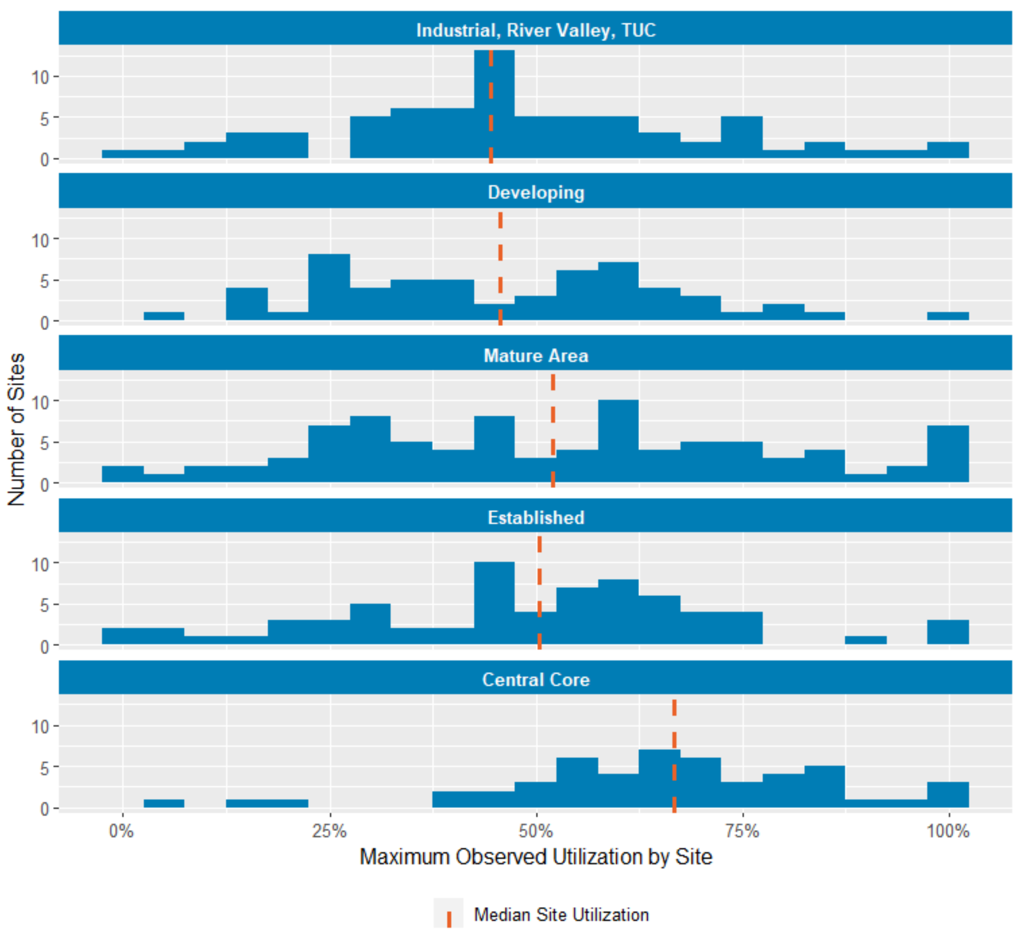


Figure 3-17 Proportion of Sites, by Utilization Bin, Neighbourhood Group (City-defined), and Time Period

Neighborhood Category	Utilization Bin	Early AM	Mid-day	Early PM	Late PM	Peak
		Proportion of Sites				
Industrial, River Valley, TUC	0 - <50%	81.8%	62.9%	82.9%	0.0%	59.7%
	50 - <75%	13.6%	22.9%	12.9%	100.0%	25.0%
	75% - <90%	4.5%	10.0%	1.4%	0.0%	9.7%
	90% - 100%	0.0%	4.3%	2.9%	0.0%	5.6%
	Site Count	22	70	70	1	72
Developing	0 - <50%	83.3%	70.9%	83.0%	22.2%	53.4%
	50 - <75%	16.7%	25.5%	14.9%	66.7%	39.7%
	75% - <90%	0.0%	3.6%	0.0%	11.1%	5.2%
	90% - 100%	0.0%	0.0%	2.1%	0.0%	1.7%
	Site Count	6	55	47	9	58
Mature Area	0 - <50%	81.8%	58.8%	74.0%	35.7%	47.8%
	50 - <75%	4.5%	24.7%	15.1%	42.9%	27.8%
	75% - <90%	9.1%	11.8%	4.1%	14.3%	13.3%
	90% - 100%	4.5%	4.7%	6.8%	7.1%	11.1%
	Site Count	22	85	73	14	90
Established	0 - <50%	84.6%	67.2%	80.0%	15.4%	50.0%
	50 - <75%	15.4%	26.6%	16.4%	69.2%	41.2%
	75% - <90%	0.0%	3.1%	1.8%	0.0%	2.9%
	90% - 100%	0.0%	3.1%	1.8%	15.4%	5.9%
	Site Count	13	64	55	13	68
Central Core	0 - <50%	46.2%	38.0%	45.0%	6.7%	14.0%
	50 - <75%	46.2%	48.0%	35.0%	63.3%	56.0%
	75% - <90%	7.7%	12.0%	10.0%	23.3%	20.0%
	90% - 100%	0.0%	2.0%	10.0%	6.7%	10.0%
	Site Count	13	50	20	30	50
Total	0 - <50%	76.3%	60.2%	77.0%	16.4%	46.7%
	50 - <75%	17.1%	28.4%	16.2%	61.2%	36.1%
	75% - <90%	5.3%	8.3%	2.6%	14.9%	10.1%
	90% - 100%	1.3%	3.1%	4.2%	7.5%	7.1%
	Site Count	76	324	265	67	338

Figure 3-18 Maximum Observed Parking Utilization (cumulative), by Time of Day and Neighbourhood Cluster

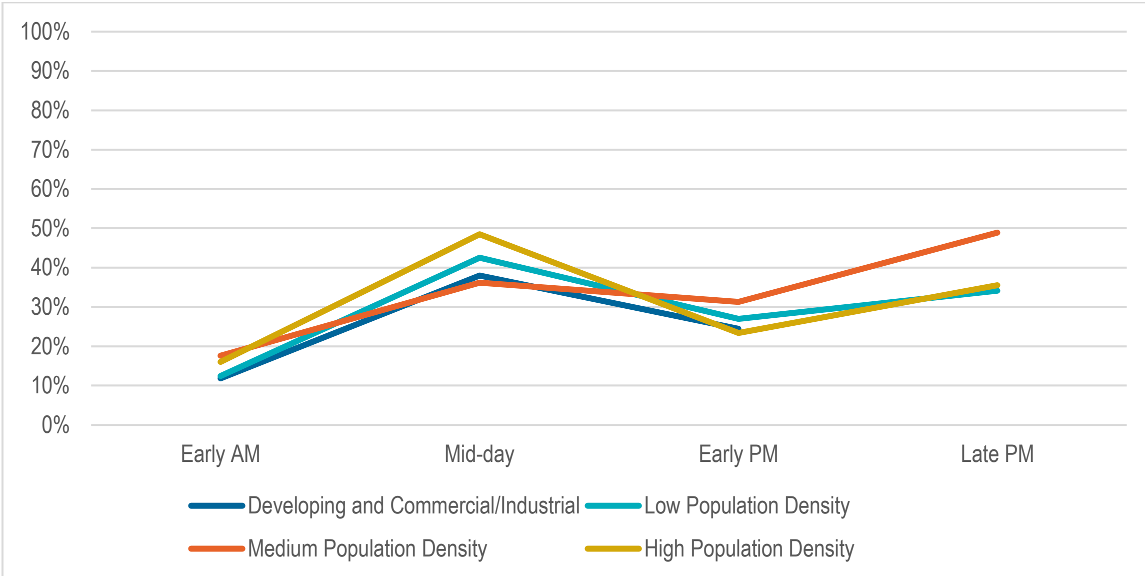


Figure 3-19 Histogram of Maximum Observed Site Utilization, by Neighbourhood Cluster

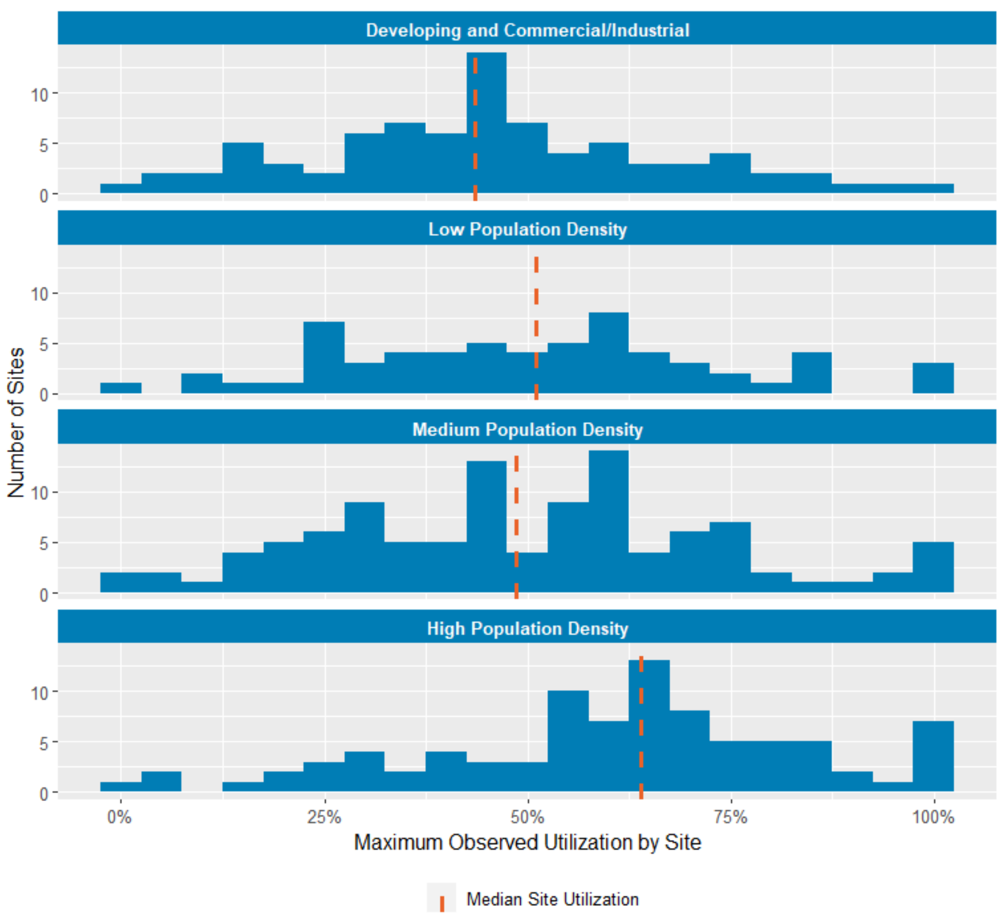


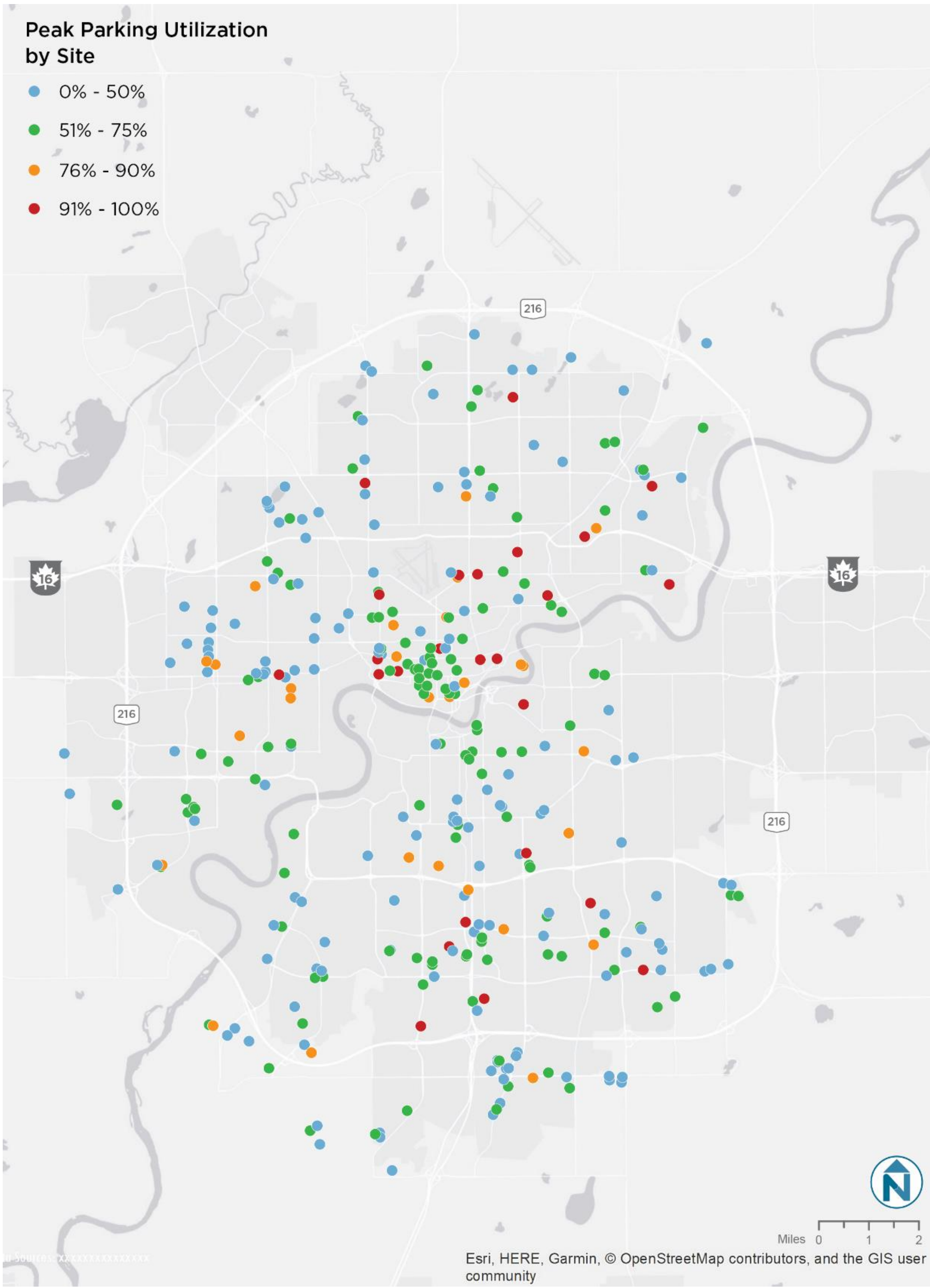
Figure 3-20 Proportion of Sites, by Utilization Bin, Neighbourhood Category, and Time Period

		Proportion of Sites				
Cluster Name	**Utilization Bin**	**Early AM**	**Mid-day**	**Early PM**	**Late PM**	**Peak**
Developing and Commercial / Industrial	0 - <50%	85.7%	68.4%	86.3%	-	64.2%
	50 - <75%	9.5%	20.3%	10.0%	-	23.5%
	75% - <90%	4.8%	8.9%	1.3%	-	8.6%
	90% - 100%	0.0%	2.5%	2.5%	-	3.7%
	Site Count	21	79	80	0	81
Low Population Density	0 - <50%	87.5%	53.4%	73.5%	27.3%	48.4%
	50 - <75%	12.5%	32.8%	22.4%	45.5%	35.5%
	75% - <90%	0.0%	8.6%	2.0%	27.3%	11.3%
	90% - 100%	0.0%	5.2%	2.0%	0.0%	4.8%
	Site Count	8	58	49	11	62
Medium Population Density	0 - <50%	86.4%	66.7%	75.9%	29.4%	50.5%
	50 - <75%	9.1%	23.2%	18.4%	52.9%	34.6%
	75% - <90%	0.0%	8.1%	2.3%	5.9%	7.5%
	90% - 100%	4.5%	2.0%	3.4%	11.8%	7.5%
	Site Count	22	99	87	17	107
High Population Density	0 - <50%	56.0%	50.0%	67.3%	7.7%	25.0%
	50 - <75%	32.0%	38.6%	16.3%	69.2%	50.0%
	75% - <90%	12.0%	8.0%	6.1%	15.4%	13.6%
	90% - 100%	0.0%	3.4%	10.2%	7.7%	11.4%
	Site Count	25	88	49	39	88
Total	0 - <50%	76.3%	60.2%	77.0%	16.4%	46.7%
	50 - <75%	17.1%	28.4%	16.2%	61.2%	36.1%
	75% - <90%	5.3%	8.3%	2.6%	14.9%	10.1%
	90% - 100%	1.3%	3.1%	4.2%	7.5%	7.1%
	Site Count	76	324	265	67	338

By Geography

Figure 3-21 illustrates the maximum observed parking utilization by site. Many of the sites in the Central Core are well below the target occupancy of 90%. As discussed, there is no clear geographic trend in how parking is utilized – it varies widely across different areas of the city.

Figure 3-21 Peak Observed Parking Utilization, by Site



By Land Use

The assessment also included a series of land use based analyses, organized by the specific categories identified in Figure 3-22. The land uses are broken down first into three broad groups – commercial, residential, and mixed use. Utilization by time of day is illustrated in Figure 3-21 through 3-23.

Commercial land uses comprise 212 sites and over 31,000 parking spaces within the dataset. At maximum observed usage (observed), **only 39% of those spaces are being used, meaning that on average over 19,000 parking spaces in commercial sites observed are open (or 96 spaces for the average site)**. Commercial uses as a whole tend to peak in the mid-day period. Within the commercial category, there are four sub-types of land use considered:

- **Commercial with only eating/drinking establishments.** On the 12 sites with only eating/drinking establishments, maximum observed occupancy is higher than commercial uses as a whole at 67%. These uses peak in the Late PM period.
- **Commercial with gym/commercial school and other commercial.** On the 45 sites with gyms or commercial schools, maximum observed occupancy is identical to other commercials as a whole at 39%. These uses peak in the mid-day period.

Residential land uses comprise 64 sites and over 6,000 spaces within the dataset. At maximum observed usage, **64% of parking is occupied, meaning that on average over 2,000 spaces are open (or 38 spaces for the average site).** Residential uses tended to peak in the late PM period (overnight). Within residential, there are three sub-types of land uses considered:

- **Condo only.** On the 30 sites with only condos, maximum observed occupancy is at 64% (identical to residential uses as a whole). These uses tended to peak in the late PM period (overnight).
- **Apartment only.** On the 34 sites with only apartments, maximum observed occupancy is at 64% (identical to residential uses as a whole). These uses tended to peak in the late PM period (overnight).

Mixed land uses (with both residential and commercial) comprise 63 sites and nearly 7,000 spaces within the dataset. At maximum observed occupancy **61% of parking is occupied, meaning that on average, over 2,500 spaces are open (or 45 spaces for the average site).**

Figure 3-22 Sites, Supply, and Utilization, by Land Use Group

Land Use Category	Land Use Subgroup	Parking Sites	Supply Surveyed					Utilization				
			Early AM	Mid-day	Early PM	Late PM	@ Max Observed Utilization	Early AM	Mid-day	Early PM	Late PM	Max Observed
Commercial	Commercial	212	4,193	31,536	32,864	184	31,536	30.9%	38.8%	30.2%	6.0%	38.8%
	Commercial with Only Eating/Drinking Establishments	12	-	557	564	3	564	-	56.2%	62.6%	66.7%	66.7%
	Commercial with Gym/Commercial School and Other Commercial	45	921	12,295	13,038	181	12,295	30.8%	38.8%	34.4%	5.0%	38.8%
Residential	Residential	64	1,978	6,764	371	5,975	5,975	41.4%	48.5%	46.1%	63.7%	63.7%
	Condo Only	30	1,287	3,307	181	2,719	2,719	43.4%	47.7%	50.3%	63.7%	63.7%
	Apartment Only	34	691	3,457	190	3,256	3,256	37.5%	49.3%	42.1%	63.8%	63.8%
Mixed Use	Mixed Use	63	1,554	6,951	5,681	1,497	6,951	39.0%	46.5%	34.2%	60.7%	60.7%

Note that these categories are not mutually exclusive – commercial only sites also include the other types of commercial sites.

Figure 3-23 Parking Utilization (cumulative), by Time of Day and Land Use (Overall Land Use Categories)

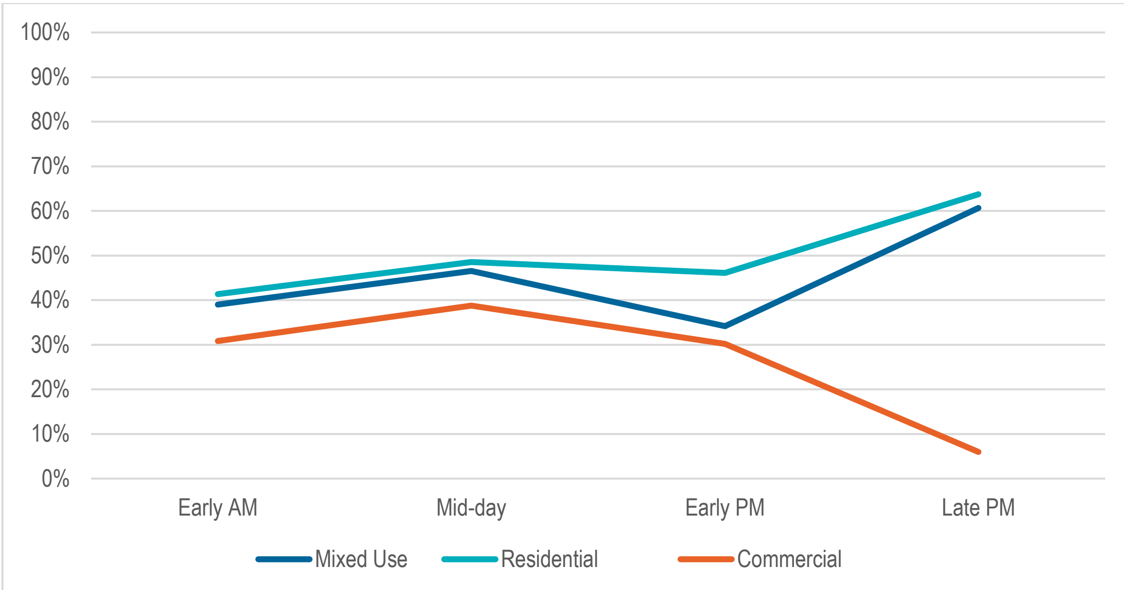


Figure 3-24 Parking Utilization (cumulative), by Time of Day and Land Use (among Commercial Uses)

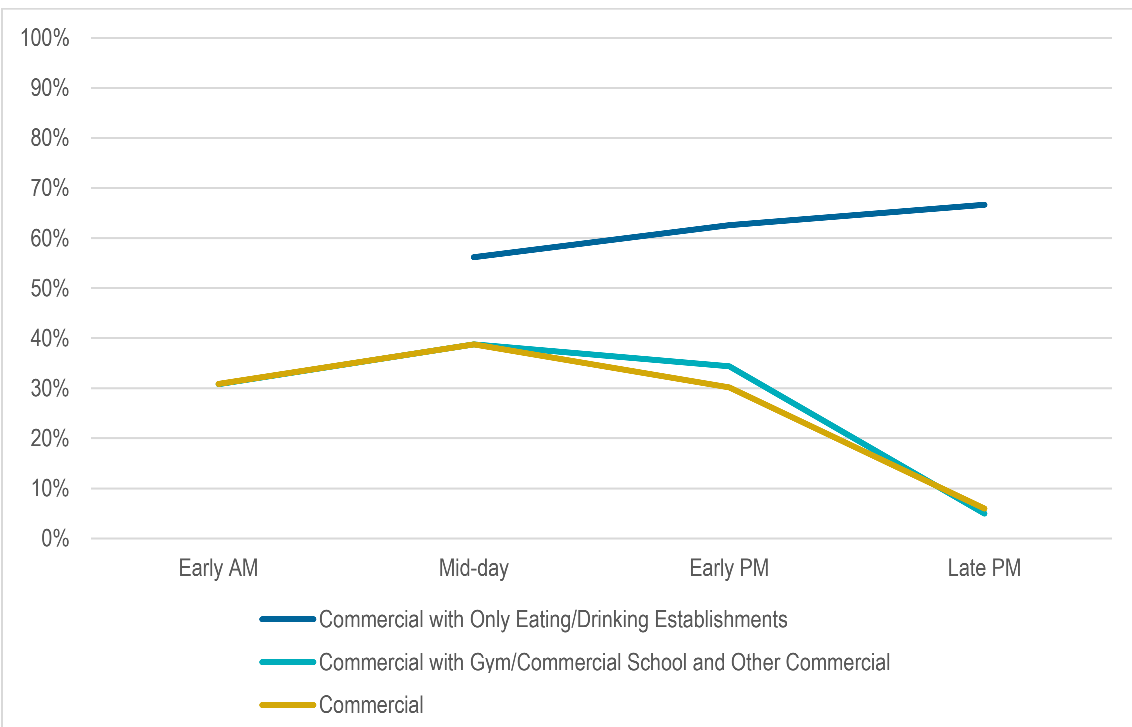
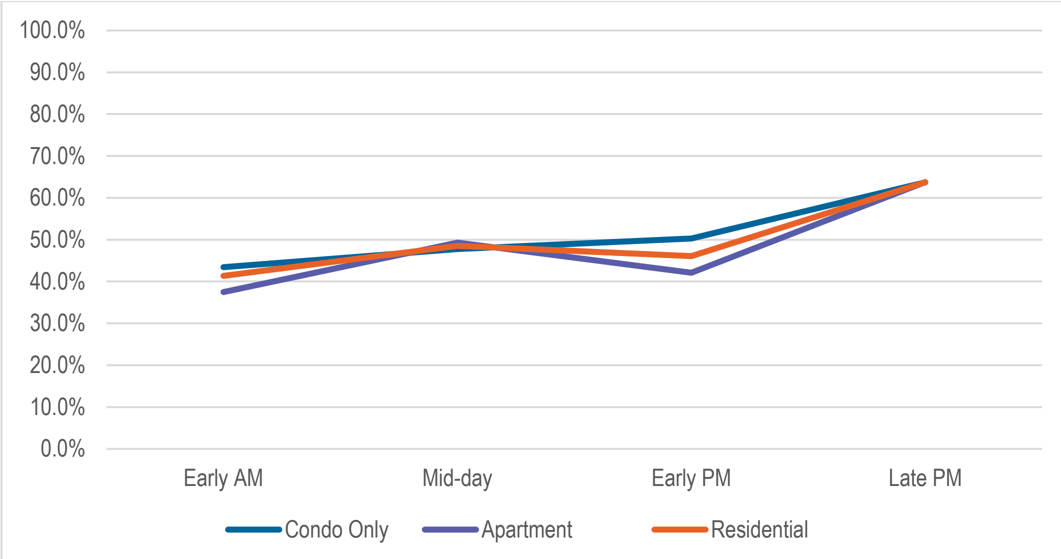


Figure 3-25 Parking Utilization (cumulative), by Time of Day and Land Use (among Residential Uses)



By Time of Year

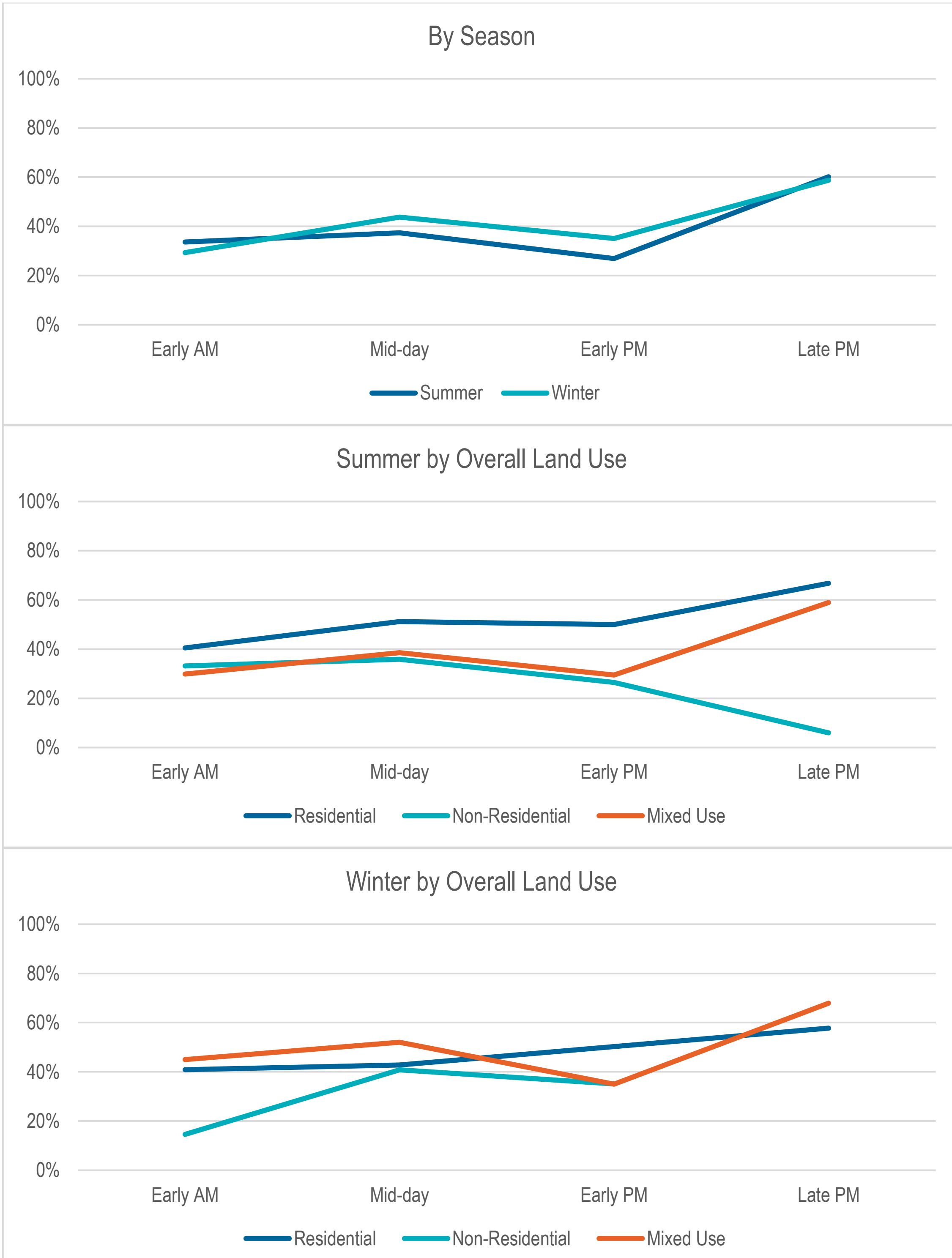
The City team conducted parking surveys in both the summer (July) and winter (November) of 2018 to identify any seasonal trends. In total, 170 sites were surveyed during the summer and 107 sites were surveyed during the winter. Figure 3-27 illustrates utilization by season, time of day, and land use. **Generally, the utilization between seasons (across sites) tended to be similar**. Mixed uses tended to peak higher in the winter, and residential uses tended to peak higher in the summer.

From these surveys, there were a total of 22 sites that were measured twice. The average changes in utilization for these sites are summarized in Figure 3-26. Nearly half of the sites (9) shifted by less than 5% (labeled 'No Change'). The sites that increased in utilization did so by an average of 21%, and the sites that decreased in utilization did so by an average of 34%. The overall average change in utilization was a 2% increase – i.e. there was minimal change in utilization across a sample of sites. There is no clear pattern in increase/decrease in utilization related to season.

Figure 3-26 Summary of Seasonal Change in Utilization

Category	Count	Summer 2018 Maximum Observed Utilization	Winter 2018 Maximum Observed Utilization	Average Shift
No Change (+/- 5%)	9	38.5%	38.4%	-0.1%
Increase	8	32.8%	53.8%	21.0%
Decrease	5	67.0%	32.8%	-34.2%
Total	22	41.0%	42.7%	1.7%

Figure 3-27 Cumulative Parking Utilization, by Season, Land Use, and Time of Day



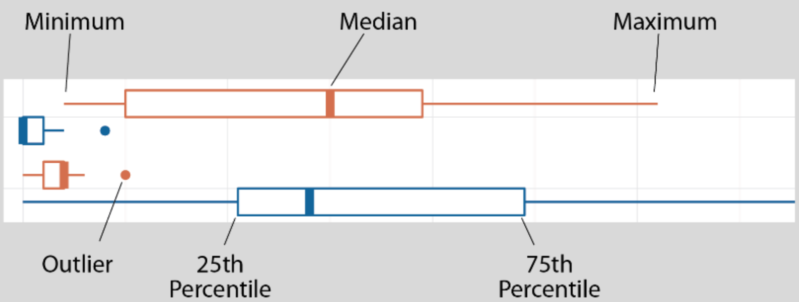
SUPPLY AND DEMAND RATIOS

The following section illustrates supply and demand ratios –how much parking is supplied and occupied relative to the built area of a given land use – using boxplots and scatter plots to show variation by land use. A note on interpreting boxplots is presented below.

Ratios are calculated in two ways – spaces per square meter of built area and square meters of built area per space. Spaces per square meter is more intuitive – a higher number indicates a higher relative supply or demand, but the inverse is also presented, as Edmonton's parking requirement ratios are described in square meters per space.

Interpreting Boxplots

Boxplots are intended to highlight variation in data. They illustrate the minimum, 25th percentile, median, 75th percentile, and maximum, as well as outliers (more than 1.5 times the bottom or top quartile).



Additional detail on interpreting these types of plots can be found at:
http://flowingdata.com/2008/02/15/how-to-read-and-use-a-box-and-whisker-plot/

By Neighbourhood Group

Using the neighbourhood group classifications, supply and demand ratio distributions were compared. Residential, commercial, and mixed uses are shown separately in the figures below.

Across uses, and as described above, **parking is supplied at a much higher rate than it is utilized.** It is provided at a generally higher rate and with more variability among commercial uses. Demand is much closer to supply for residential uses, which also had higher utilization overall.

Figure 3-28 Ratio Boxplot, by Neighbourhood Group and Overall Land Use

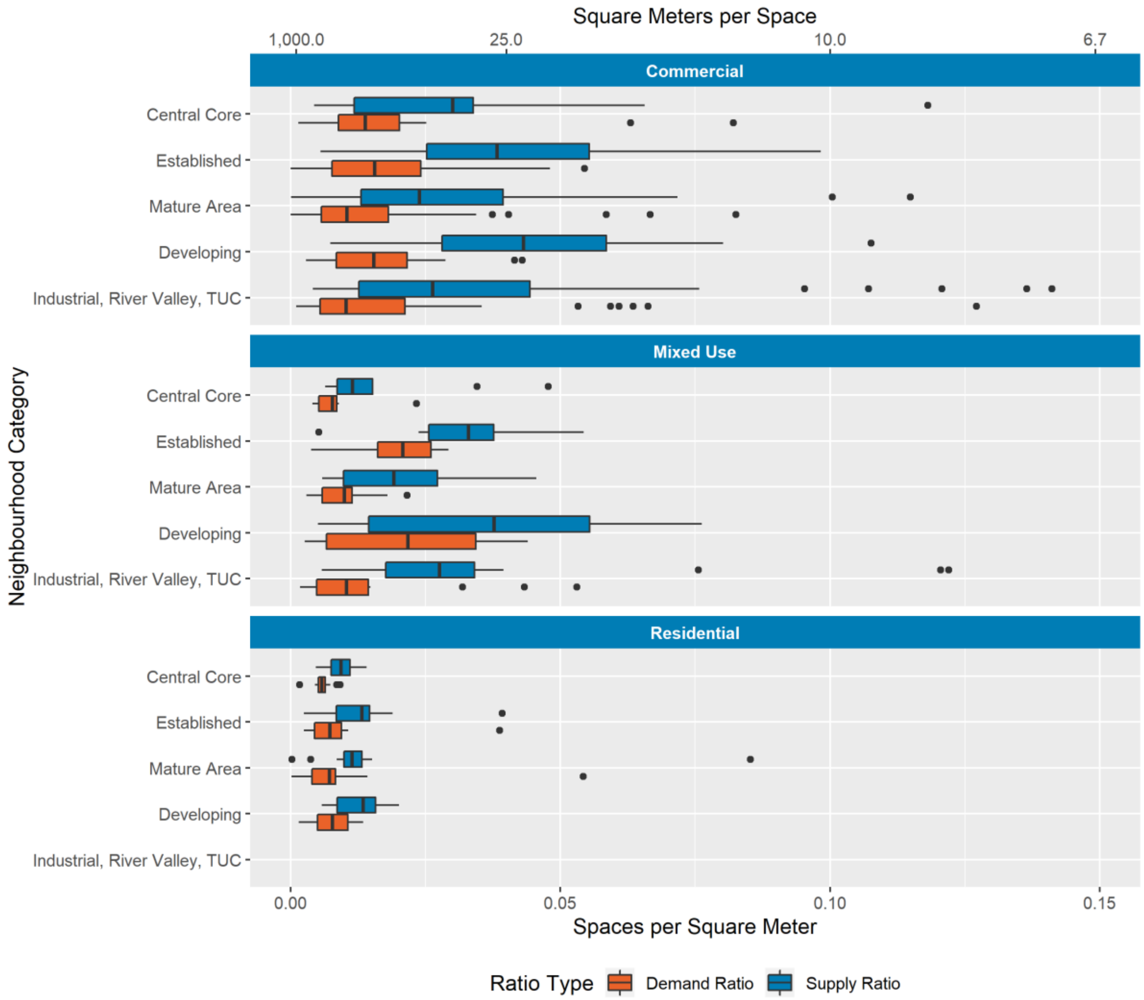
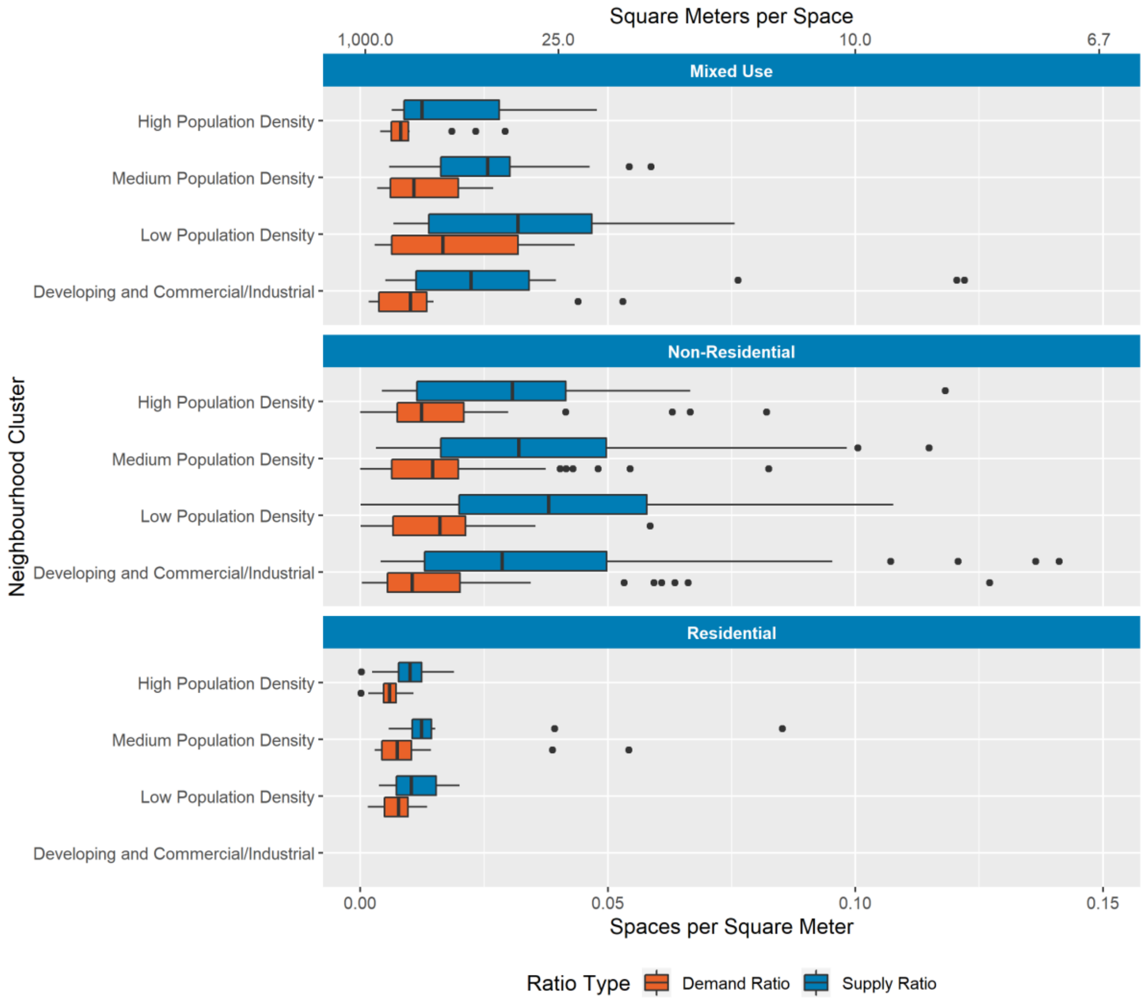


Figure 3-29 Ratio Boxplot, by Neighbourhood Cluster and Overall Land Use



By Land Use

The land use categories were also used to analyze supply and demand ratios by certain land use categories. Scatterplots are presented to illustrate the relationship between supply and demand ratios. Diagonal envelopes illustrating utilization are show for reference.

Commercial

The variances of supply and demand ratios among commercial uses considered are illustrated in Figure 3-30 and Figure 3-31. **Eating and drinking establishments have some of the highest demand ratios of land uses considered in this study, but parking is still over-supplied at these uses.**

Figure 3-30 Ratio Boxplot, by Commercial Land Use

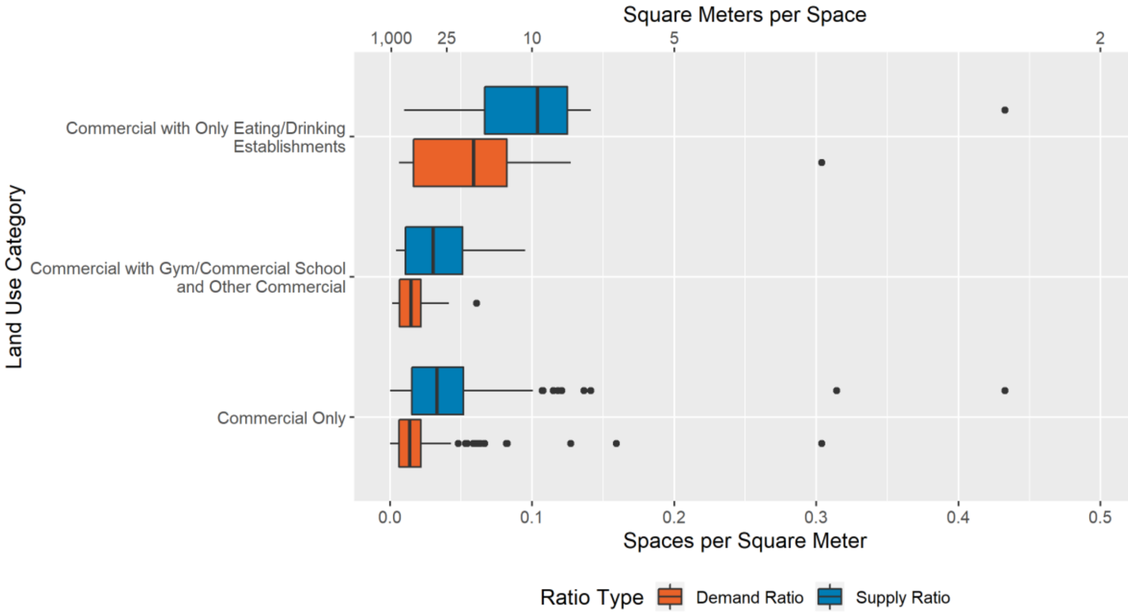
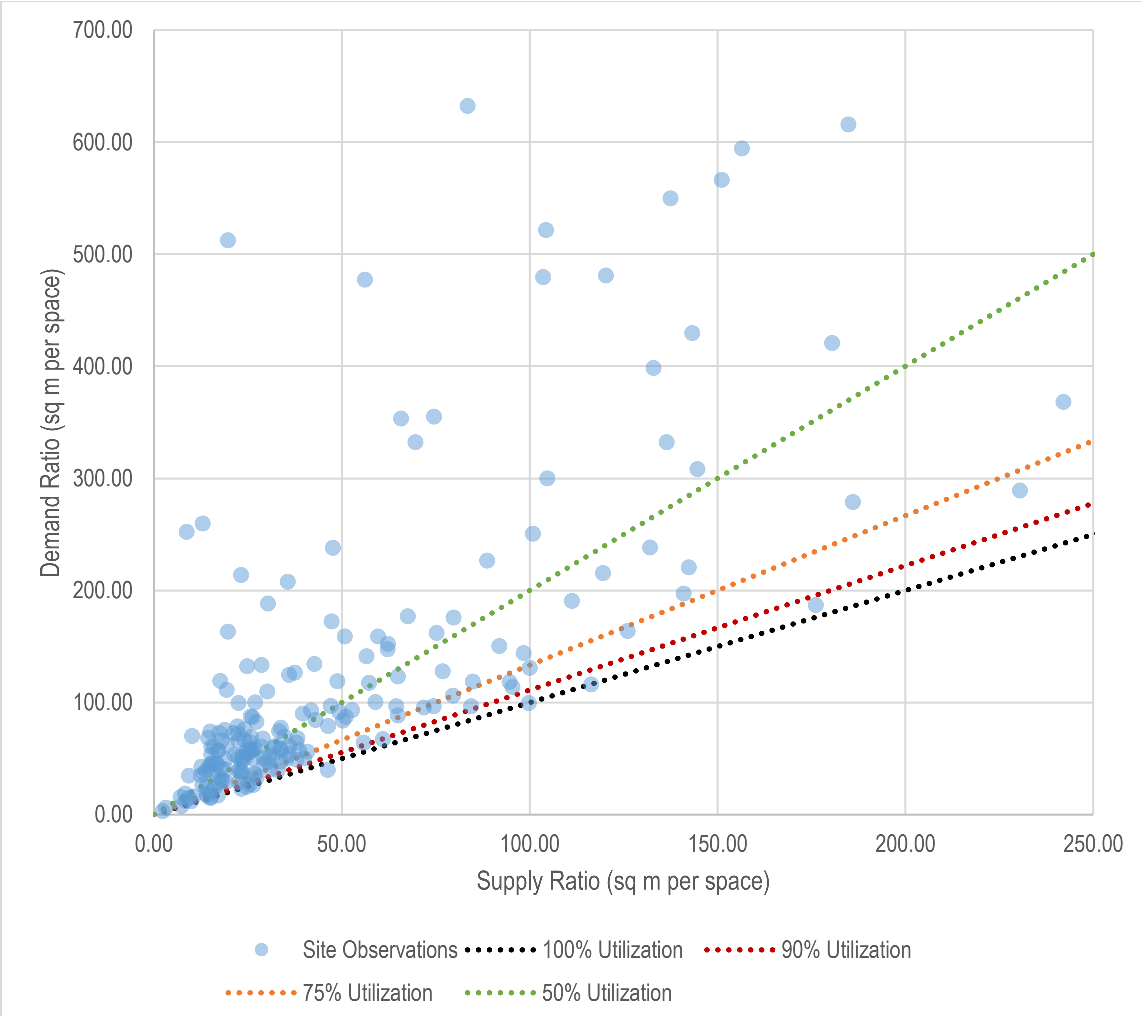


Figure 3-31 Supply and Demand Ratio Scatterplot among Commercial Uses (N=207)



Residential

The variances of supply and demand ratios among residential uses are illustrated in Figure 3-32 and Figure 3-33. The specific residential land uses considered look very similar to residential land uses overall – **parking is over-supplied a similar rate across all residential categories.** On average, the over-supply magnitude is smaller than commercial land uses on average.

Figure 3-32 Ratio Boxplot, by Residential Land Use

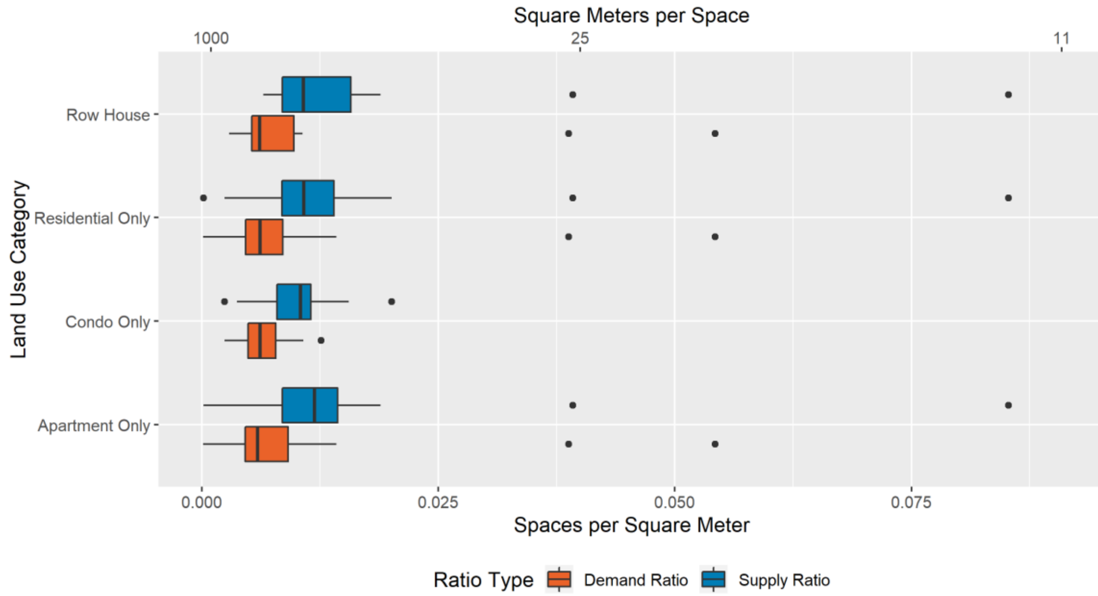
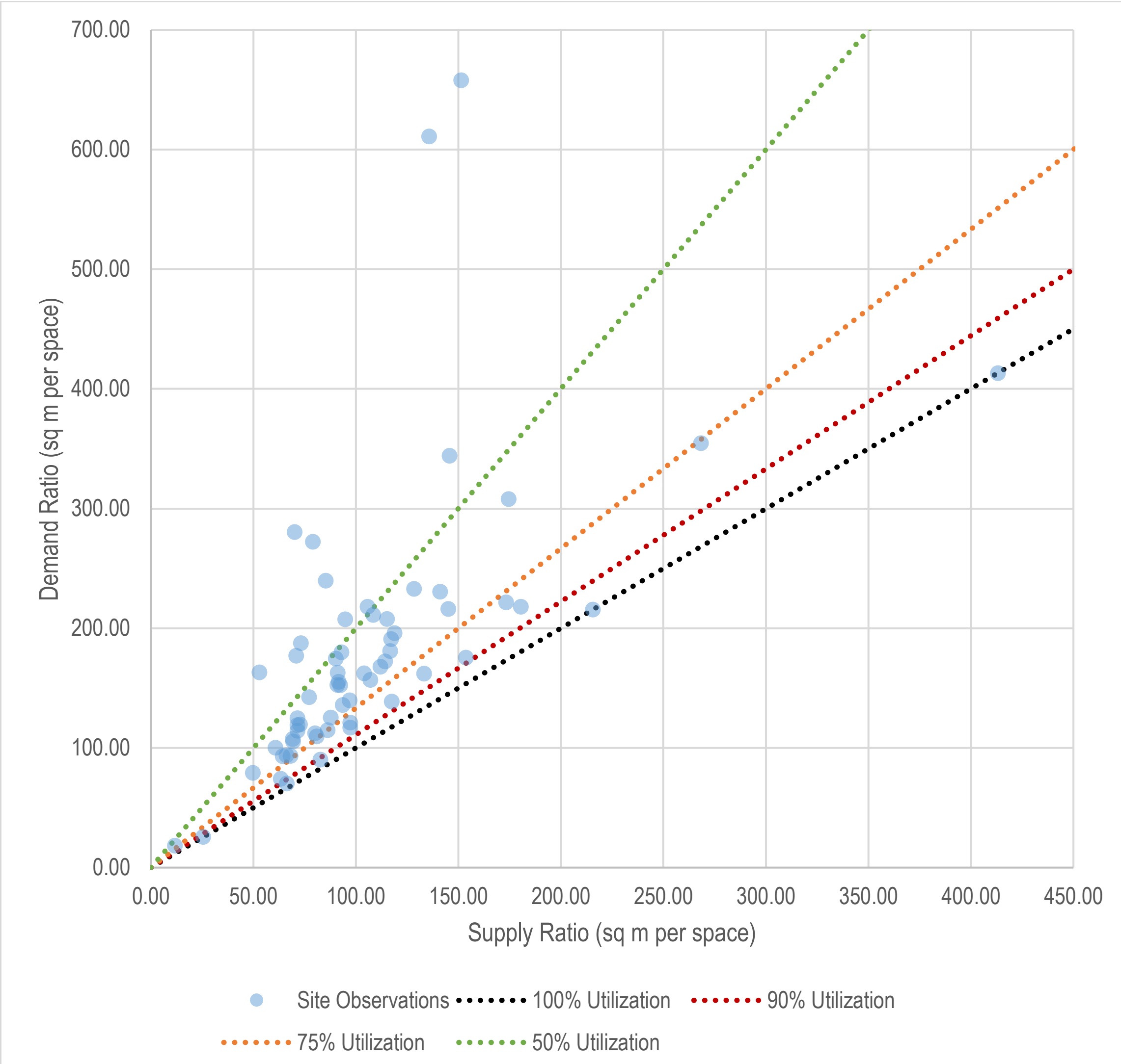


Figure 3-33 Supply and Demand Ratio Scatterplot among Residential Uses (N=63)



Mixed Land Uses

The variances of supply and demand ratios among overall land uses are illustrated in Figure 3-34 and Figure 3-35. The boxplot highlights the contrast between commercial, residential, and mixed land uses. **Parking is oversupplied to the greatest extent among commercial land uses, and to a lesser extent at mixed land uses.** As previously stated, residential land uses have the smallest magnitude of over-supply.

Figure 3-34 Ratio Boxplot, by Overall Land Use

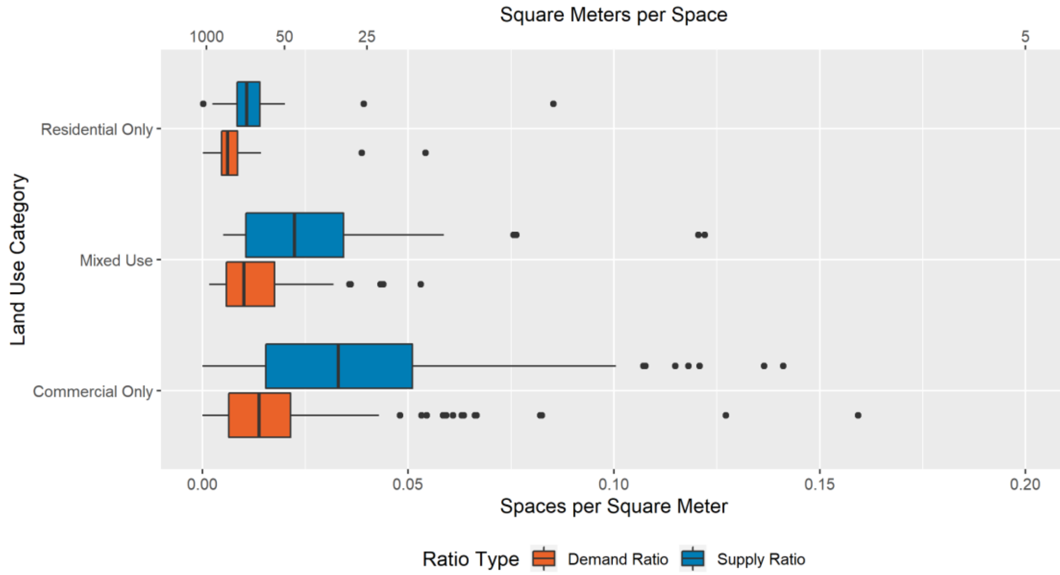
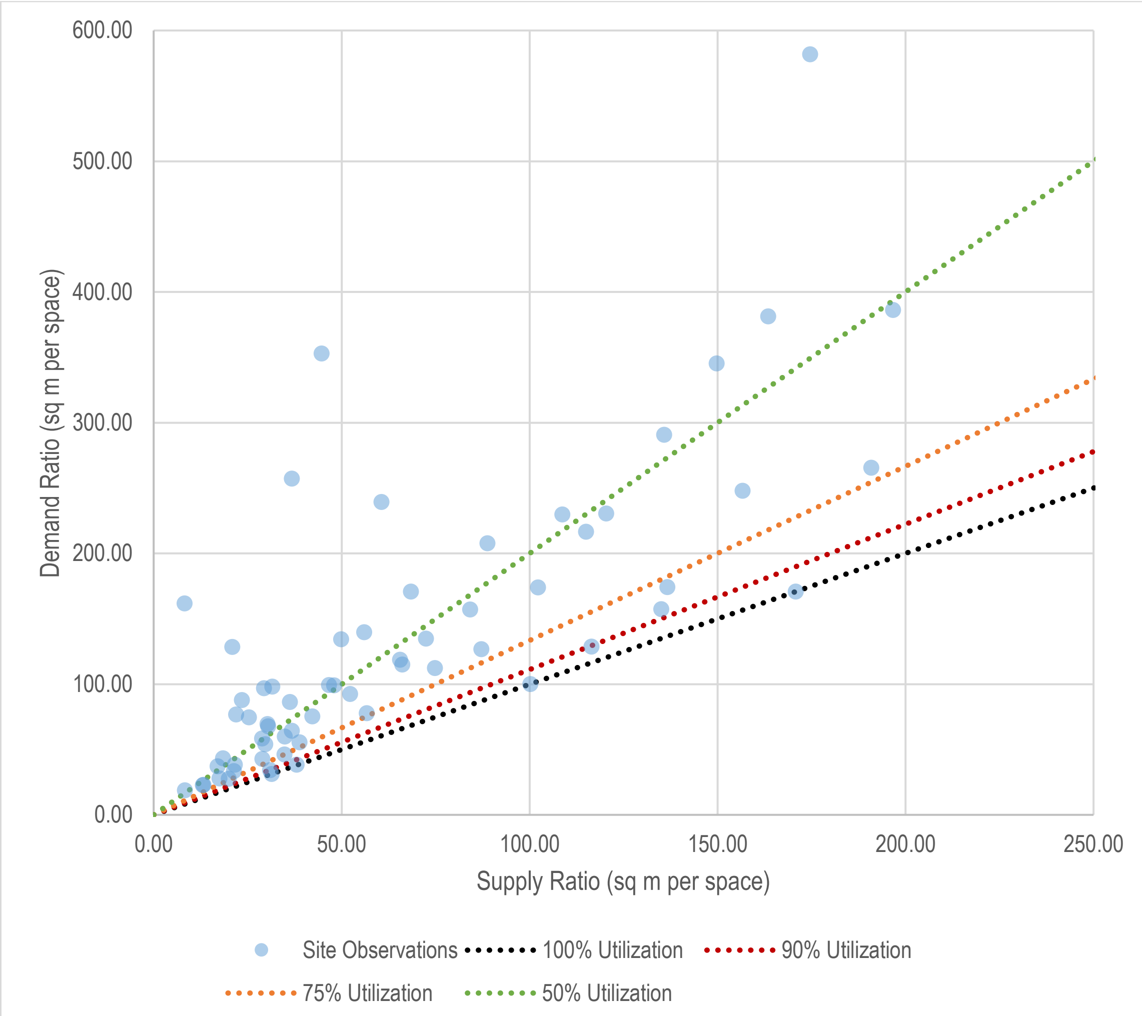


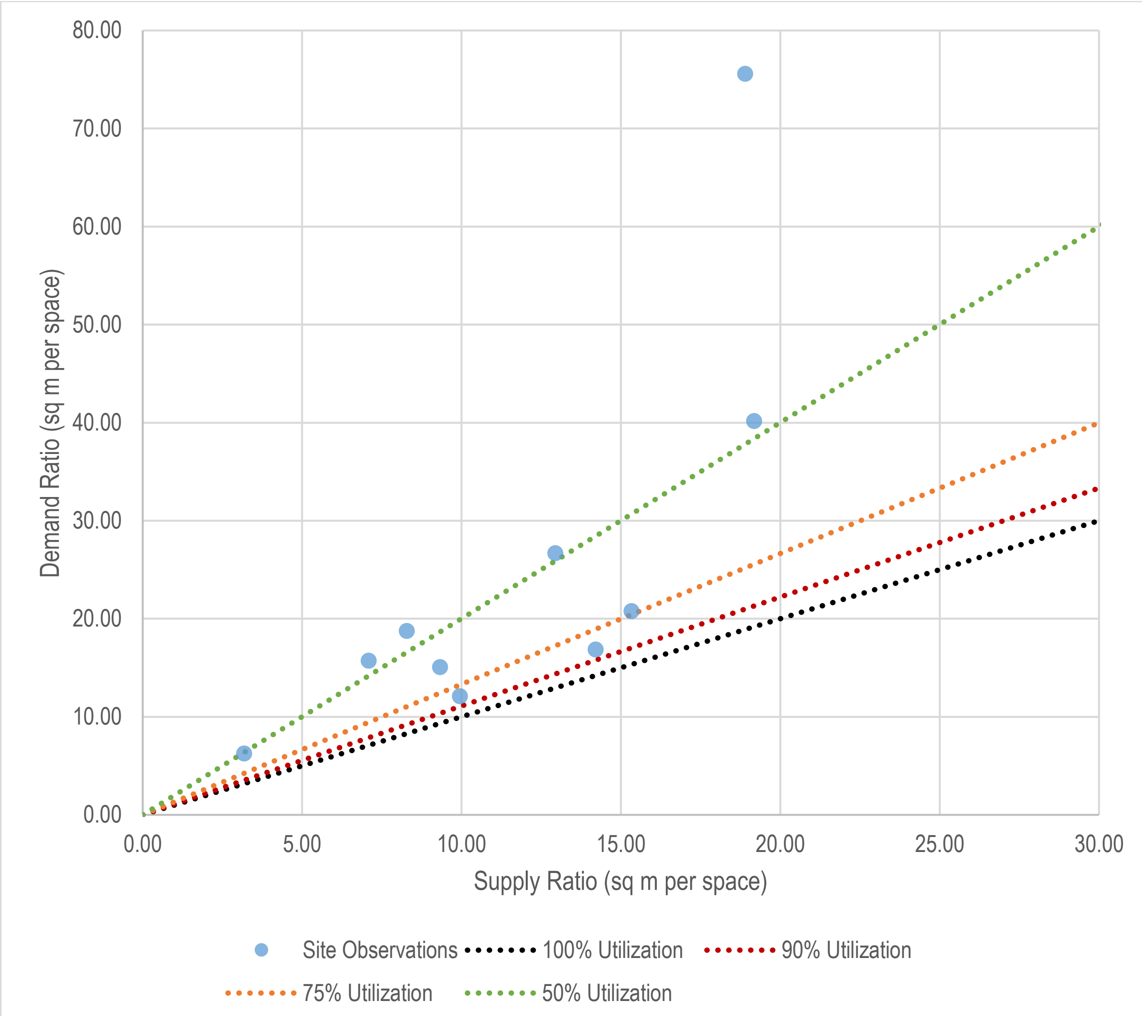
Figure 3-35 Supply and Demand Ratio Scatterplot among Mixed Use (N=63)



Tim Horton's

The supply and demand ratios for ten sites with Tim Horton's restaurants are illustrated in Figure 3-36. There is variance in supply and demand among sites with Tim Horton's – two sites have demand nearing supply, while the others have utilization less than 75%. Supply and demand ratios both vary widely.

Figure 3-36 Supply and Demand Ratio Scatterplot among Sites with Tim Horton's (N=10)



4 KEY FINDINGS

1. **Parking is over-supplied across geography and land uses considered.** Based on observed data, parking is generally over-supplied across most land uses and locations in Edmonton. Some specific sites or neighbourhoods have high parking occupancies at certain times of day. However, those findings are not reflective of overall citywide patterns and are indicative of site-specific management challenges.
2. **Parking is supplied and utilized at rates that have no discernable relationship with land use or neighbourhood context.** This report analyzes parking supply and utilization in relation to many potential land use and demographic factors. The consistent finding is that parking supply and utilization varies widely across the city and there is no easily identifiable, consistent factor determining this relationship.
3. **The City should prioritize further evaluation of a substantial reduction and/or elimination of minimum parking requirements.** As demonstrated in the analysis, there is wide variation in how parking is supplied and utilized by both land use and geographic area, and the relationships considered in this report are very tenuous.

   Therefore, parking supply should be primarily determined by local market demand, not prescriptive supply ratios in code. Parking regulations should ultimately provide flexibility for each site or project, while reflecting broader policy goals to reduce driving and promote mobility choices.
4. **City parking regulations and parking management practices can play a stronger role in how parking is utilized.** Where parking is utilized at a high rate (which was rare among sites analyzed), the City should consider pricing on-street parking, incentivizing the pricing of off-street parking, as well as regulations to manage parking demand, such as programs and infrastructure encouraging the use of transit, biking, walking, and shared vehicle trips. A Transportation Management Association (TMA), or some other organization directing management and regulation of on- and off-street parking as integrated inventory, would also help to maximize the utility of existing parking.